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ABSTRACT

This curriculum guide to the physical sciences was prepared for use in high schools in Duval County, Jacksonville, Florida. Courses covered for grades 10-12 are chemistry, advanced chemistry, physical science, physics, advanced physics, science survey/physical, and science research. For each course, the following elements are included: notes to the teacher, a course outline, detailed performance objectives, a key to the recommended instructional materials, and a key to laboratory resources. General recommendations and guidelines are provided for science research. (CMG)

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1982

SENIOR HIGH PHYSICAL SCIENCES

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Science Research	SR
Science Survey / Physical	SS/P

CURRICULUM DEVELOPMENT AND MLST STATUS

SECONDARY SCIENCE COURSES

1982-1983

COURSE	GRADE LEVEL	CURRICULUM	MLST
Anatomy and Physiology	SHS	No changes	On line
Biology I	SHS	No changes	On line
Biology I, Adv.	JHS/SHS	Slight revisions	On line
Biology II, Adv.	SHS	New	Field Test
Chemistry I	SHS	No changes	On line
Chemistry I, Adv.	SHS	Slight revisions	On line
Chemistry II, Adv.	SHS	New	Field Test
Earth/Physical Science, Adv.	JHS	New	Field Test*
Earth Science	SHS	No changes	On line
Earth Science 9	JHS	New	Field Test
Ecology	SHS	No changes	On line
Life Science 7	JHS	No changes	On line
Life Science 7, Adv.	JHS	No changes	On line
Marine Biology I	SHS	No changes	On line
Marine Biology II, Adv.	SHS	Major revisions	Field Test
Marine Science	SHS	Slight revisions	On line
Physical Science 8	JHS	Slight revisions	On line
Physical Science II	SHS	No changes	On line
Physics I	SHS	Slight revisions	On line
Physics I, Adv.	SHS	No changes	On line
Physics II B, Adv.	SHS	New	Field Test
Science Survey, Biol.	SHS	No changes	On line
Science Survey, E/S	SHS	No changes	On line
Science Survey, Phys.	SHS	Slight revisions	On line
Zoology	SHS	Slight revisions	On line

* In 10 junior high schools; students in all other schools take on-line MLST.

INTRODUCTION
CHEMISTRY I

State Accreditator Number. .	1316
Course Code Number	2401
F.T.E. Category.	1.10
Instructional Level.	Standard
Report Card Abbreviation . .	Chemistry I
Length of Course	Year
Credit	1 Science credit
Grade Level.	10, 11, 12

Prerequisites

Algebra I with "C" or better

Textbook(s)

Metcalfe, H. C., et al, Modern Chemistry (New York: Holt, Rinehart, and Winston, 1978).

Notes to Teachers

Changes have been made in the content and format of the Course Outline and in the Performance Objectives for Chemistry I. Full objectives are now included in addition to the Minimum Level Skills objectives. Students are to develop laboratory skills as well as content knowledge.

The Minimum Level Skills (MLS) objectives are indicated with an asterisk (*), and will be the only objectives tested in the MLST. The "Teaching Time" listed on the "Key to Instructional Materials" is a suggested maximum time for each objective to help insure that all MLS objectives can be met by MLST time.

Laboratory skills are indicated with a plus sign (+). Suggested resources for teaching the laboratory skills have been listed at the end of this section of the teacher's guide. Other resources may be substituted for or added to suggested laboratory resources. Supplementary materials are listed in rank order of importance.

CHEMISTRY I

1.0 Measurement/Classification of Matter

- 1.1 Metric System
  - 1.1.1 Prefixes
  - +1.1.2 Measurement: mass, volume, density
  - 1.1.3 Metric conversions
- *1.2 Scientific Notation
- 1.3 Significant Figures
- 1.4 Elements/Compounds/Mixtures
  - +1.4.1 Classifications in lab: elements, compounds, mixtures
  - *1.4.2 Classes of elements
  - *1.4.3 Names/Symbols of elements
  - *1.4.4 Law of Definite Composition
  - 1.4.5 Physical/Chemical properties
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- 2.2 Structure of the Atom
  - 2.2.1 Nucleus/Energy levels
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- 2.3 Isotopes/Nuclides
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  - *2.4.2 Calculations
- 2.5 Mole Concept Calculations
  - *2.5.1 Avogadro number
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  - 2.5.3 Moles from grams/Gram atomic weight
- 2.6 Atomic Weight
- 2.7 Spectra of Atoms
  - 2.7.1 Bright line spectrum
  - +2.7.2 Flame tests, salts
- 2.8 Quantum Numbers
  - *2.8.1 Principal, orbital
  - 2.8.2 Magnetic, spin
- *2.9 Electron Arrangement in Atoms
  - 2.9.1 Number of electrons
  - 2.9.2 Electron configuration
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  - 3.1.2 Groups/Periods
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- 3.2 Use of Periodic Table to Predict
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- 3.3 Chemical Bonding
  - 3.3.1 Formation
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  - *3.3.3 Molecules/Ions
  - *3.3.4 Polar covalent bond
  - *3.3.5 Electron sharing
- *3.4 Oxidation/Reduction
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  - 3.4.2 Rules: oxidation numbers

* Indicates Minimum Level Skills
\+ Indicates Laboratory Skills

CHEMISTRY I

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  - *4.7.2 Classification
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- 4.9 Activity Series of Elements
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  - 8.1.1 Structural characteristics
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CHEMISTRY I

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  - 10.4.1 Radioactive decay
  - 10.4.2 Definition of half-life
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- 10.11 Nuclear Energy/Controversy

PERFORMANCE OBJECTIVES
CHEMISTRY I

To demonstrate the ability to recall and apply knowledge of measurement and classification of matter; structure of matter, periodic table and chemical bonding, formula writing, nomenclature, chemical equations, and stoichiometry; gases and gas laws, liquids, solids and water; solution process and ionization; and acids, bases, salts, pH, and titration, students will master the performance objectives listed below. Successful completion of this course is based on teacher judgement and the requirement that students pass the Minimum Level Skills Test.

Performance Objectives

1.0 Measurement/Classification of Matter

1.1 To demonstrate knowledge of metric units, students will:

(1) identify kilo-, deci-, centi-, and milli- as prefixes used in the metric system;

+(2) use metric apparatus to make measurements in mass, volume, and density; and

(3) convert given metric units to other specified metric units.

*1.2 Students will identify the scientific notation for a specified number.

1.3 Students will identify the number of significant figures in a specified number.

1.4 To demonstrate knowledge of elements, compounds, and mixtures, students will:

+(1) use laboratory methods to classify specified substances as elements, compounds, or mixtures; and

*(2) identify two classes of elements;

*(3) identify the name or symbol for a specified element, atomic numbers 1-20;

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* Indicates Minimum Level Skills
\+ Indicates Laboratory Skills

*(4) select a statement of the Law of Definite Composition;

(5) classify a property as physical or chemical; and

*(6) identify whether given changes are physical changes or chemical changes.

*1.5 Students will identify entropy as the state of disorder of a system.

2.0 Structure of Matter

2.1 Students will write four properties of atoms based on the chemical and physical properties of matter.

2.2 To demonstrate knowledge of the structure of the atom, students will:

(1) identify the location in the atom of the nucleus and the energy levels; and

*(2) identify protons, neutrons, or electrons as atomic particles having a positive charge, no charge, or a negative charge respectively.

2.3 Students will identify the definition of isotope and nuclide.

2.4 To demonstrate knowledge of atomic number and mass number, students will:

(1) identify definitions of atomic number and mass number; and

*(2) determine the atomic number or mass number of an element when the number of protons, neutrons, and electrons in the atom is specified.

2.5 To demonstrate knowledge of mole concept calculations, students will:

*(1) identify the number of atoms in one mole of an element;

+(2) calculate the number of moles of an element from grams of an element using data collected in the laboratory; and

(3) calculate the number of moles of an element when given a specified number of grams and the gram atomic weight of the element.

2.6 Students will identify the definition of atomic weight.

2.7 To demonstrate knowledge of the spectra of atoms, students will:

(1) recognize that lines of light produced in a bright line spectrum by excited atoms represent only certain energies; and

+(2) identify a metal salt by the color it gives to a flame, using laboratory methods.

2.8 To demonstrate knowledge of quantum numbers, students will identify the definition of:

*(1) principal or orbital quantum number; and

(2) magnetic or spin quantum number.

*2.9 To demonstrate knowledge of the electron arrangement in atoms, students will:

(1) identify the maximum number of electrons which can be found in a specified energy level;

(2) identify the electron configuration for a specified element, atomic numbers 1-20; and

(3) identify the electron dot formula for an atom in Groups I through VIII, atomic numbers 1-20.

3.0 Periodic Table/Chemical Bonding

3.1 To demonstrate knowledge of the arrangement of the Periodic Table students will:

*(1) identify a statement of the Periodic Law;

(2) identify a group or period on the Periodic Table;

*(3) identify the location of the transition elements on the Periodic Table; and

*(4) identify the location of the metalloids on the Periodic Table.

3.2 Students will use the Periodic Table to predict:

(1) the relative sizes of atoms in groups or periods;

(2) the relative amount of ionization energy required to remove an electron from an atom as one proceeds down a group; and

(3) the group of elements on the Periodic Table which would have the highest positive electron affinities.

3.3 To demonstrate knowledge of chemical bonding, students will:

(1) describe in writing how chemical bonds are produced;

(2) identify the location of valence electrons in an atom;

*(3) identify the type of particle produced by electron sharing or transfer as a molecule or an ion;

*(4) identify the type of bond in which there is an unequal attraction for the shared electrons and an unbalanced distribution of charge as a polar covalent bond; and

*(5) identify a covalent bond as being formed by electron sharing.

*3.4 To demonstrate knowledge of oxidation and reduction, students will:

(1) identify a definition for oxidation or reduction;

(2) identify the oxidation number of an element in a binary compound.

3.5 To demonstrate knowledge of electron dot formulas, students will identify:

(1) the correct electron dot formula for an ionic compound of a Group I or Group II metal with a Group VII non-metal, and

(2) the correct electron dot formula for covalent molecules containing hydrogen: H_2O, H_2O_2, CH_4, or NH_3.

3.6 To demonstrate knowledge of electronegativity, students will:

(1) identify a definition of electronegativity;

(2) use the Periodic Table of electronegativity to determine the binary compound having a non-polar covalent, a polar covalent, or an ionic bond; and

*(3) identify metals as the class of elements having the lowest electronegativity and nonmetals as the class of elements having the lowest electronegativity; and

+(4) construct models of covalent substances and explain how the shapes and structures of the molecules are related to their polarity.

4.0 Chemical Equations, Nomenclature, and Stoichiometry

4.1 Students will identify the formulas and charges for common ions.

4.2 To demonstrate knowledge of chemical formula writing and naming of compounds, students will:

*(1) identify the name or formula for a compound using the stock system of nomenclature.

(2) identify the name or formula for a compound using the old system of nomenclature; and

*(3) identify the correct formula or name of a compound using Greek numerical prefixes.

4.3 To demonstrate knowledge of calculations involving chemical formulas, students will:

*(1) calculate the formula weight or molecular weight of a specified compound given the formula of the compound;

*(2) calculate the percentage of a specified element given the formula of the compound;

+(3) determine the percentage of oxygen in potassium chlorate from the data collected in the laboratory; and

(4) calculate the empirical or molecular formula for a compound from percentage composition data and also molecular weight when necessary.

4.4 Students will identify a statement of the Law of Definite Composition or of the Law of Multiple Proportions.

4.5 To demonstrate knowledge of the mole and of gram molecular weight, students will:

(1) identify the definition of mole as having the Avogadro number of any kind of chemical units; and

*(2) calculate the number of moles of a compound in a specified mass in grams of that compound.

4.6 To demonstrate knowledge of writing and balancing equations, students will:

*(1) select the coefficients which will balance a given equation; and

(2) write a balanced chemical equation for a specified composition, decomposition, replacement, or ionic reaction when reactants are specified.

4.7 To demonstrate knowledge of general types of reactions, students will:

+(1) identify the type of reaction and write the chemical equations for composition, decomposition, replacement, and ionic reactions from observations made in the laboratory; and

*(2) identify a specified reaction as composition, decomposition, or replacement.

*4.8 Students will identify a statement indicating that amounts of reactants and products in a chemical system at equilibrium remain unchanged.

4.9 Given an Activity Series Table, students will use the activity series to identify whether a specified metal will replace hydrogen from a specified compound.

4.10 To demonstrate knowledge of stoichiometry, students will:

*(1) calculate the number of moles of a substance required to react with a specified number of moles of a second reactant when given the balanced chemical equation;

(2) calculate the number of grams of a reactant required to produce a specified number of moles of a product given the balanced chemical equation; and

(3) calculate the number of grams of a reactant required to produce a specified number of grams of a product given the balanced chemical equation.

5.0 Gases and the Gas Laws

5.1 Students will state the three basic assumptions of the Kinetic Theory.

*5.2 Students will identify expansion, pressure, low density, or diffusion as the properties of a gas.

5.3 To demonstrate knowledge of the Kinetic Theory description of a gas, students will:

(1) write a description of an ideal gas; and

(2) explain the relationship between average kinetic energy of gases and temperature.

5.4 Students will identify van der Waals forces as the attractive forces between non-polar gaseous molecules.

5.5 Students will identify in Celsius degrees and millimeters of mercury the conditions of temperature and pressure which are standard.

*5.6 Students will identify temperature and pressure as the conditions which determine the volume that would be occupied by a given number of gas molecules.

5.7 Students will determine the correct Kelvin temperature when given the Celsius temperature.

5.8 Students will make pressure corrections when a gas is collected over mercury or water.

5.9 Students will state Boyle's Law and Charles' Law.

5.10 Students will identify a mathematical equation which represents the combination of Boyle's and Charles' Laws.

5.11 Students will state Avogadro's Principle.

5.12 To demonstrate knowledge of molar volume, students will:

*(1) identify the statement that the volume occupied by one mole of any gas at STP is 22.4 liters; and

+(2) determine the volume occupied by one mole of a gas at STP from data collected in the laboratory.

5.13 Students will identify the definition of the density of a gas.

5.14 To demonstrate knowledge of chemical problems involving gases, students will:

(1) calculate the volume of a gas at a second pressure given a volume of a gas at a specified pressure, temperature remaining constant, and calculate the volume of a gas at a specified temperature, pressure remaining constant;

*(2) calculate the volume of a gas at STP when given the volume of the gas at conditions other than STP using, Boyle's and Charles' Law combined.

(3) calculate the volume of a dry gas at STP when given the volume of the gas collected over water at conditions other than STP and given water vapor pressure;

*(4) identify the numerical value for the number of liters of a gas produced at STP from a specified balanced chemical equation when given the number of liters of a gaseous reactant; and

(5) calculate the number of liters of a gas produced at STP using a specified balanced chemical equation when given moles of a specific reactant.

6.0 Liquids, Solids, and Water

6.1 Students will state four properties common to all liquids.

6.2 Students will describe the molecular motion which occurs in liquids.

6.3 To demonstrate knowledge of LeChatelier's Principle as applied to physical equilibrium, students will:

*(1) identify a statement which describes a physical equilibrium; and

(2) identify the direction that a liquid-vapor equilibrium will shift if heat is added to or removed from the system.

6.4 Students will identify a statement of the dependence of the boiling point of a specified liquid on prevailing atmospheric pressure.

6.5 Students will identify definite shape, definite volume, noncompressibility, and very slow diffusion as the four properties common to all solids.

6.6 To demonstrate knowledge of phase changes in solids, students will:

(1) identify a definition of sublimation; and

(2) identify an equation indicating a solid-vapor equilibrium.

6.7 To demonstrate knowledge of crystalline and amorphous solids, students will:

(1) identify definitions of crystalline and amorphous solids; and

(2) identify NaCl, diamond, ice, or copper as crystalline solids, or identify glass and paraffin as amorphous solids.

6.8 To demonstrate knowledge of the properties of water, students will:

(1) identify the temperature at which water has its maximum density; and

+(2) identify chemical and physical properties of water based on laboratory observations.

6.9 To demonstrate knowledge of the structure of the water molecule, students will:

*(1) identify the structural formula for the water molecule;

(2) describe the structure of the water molecule including its shape and polarity.

*6.10 Students will identify a line between two points as the freezing phase of water on a change of phase diagram.

*6.11 Students will identify the definition of hydrogen bonding.

7.0 Solution Process Ionization

7.1 To demonstrate knowledge of solute, solvent, and solution, students will:

*(1) identify the definition of solute or solvent;

(2) identify the definition of a solution; and

*(3) identify water as the most common solvent.

*7.2 Students will identify the definition of electrolyte or nonelectrolyte.

7.3 Students will identify the type of a specified example of a solution.

7.4 To demonstrate knowledge of the selectivity of solvents, students will:

*(1) identify the statement, "Like dissolves like," as a general rule of solubility; and

+(2) observe the selectivity of solvents in the laboratory.

7.5 To demonstrate knowledge of solution equilibrium, students will:

(1) identify a definition of saturated solution; and

*(2) identify the direction of shift of an endothermic solution process when heat is added to the equilibrium system (LeChatelier's Principle).

7.6 Students will identify how changes in pressure and temperature affect changes in the solubility of a solid in a liquid and the solubility of a gas in a liquid.

7.7 Students will list three factors which could increase the rate of dissolving of solids in a liquid.

7.8 To demonstrate knowledge of solution concentrations, students will:

(1) state the difference between a dilute solution and a concentrated solution; and

(2) identify the definition of a one molal solution.

7.9 To demonstrate problem solving ability involving solutions, students will calculate the molality of a solution when the weight of solute and weight of solvent are specified;

7.10 Students will explain why solutions of electrolytes will conduct an electric current and solutions of nonelectrolytes will not conduct electricity.

7.11 To demonstrate knowledge of the theory of ionization, students will:

(1) state the three assumptions of the theory of ionization; and

*(2) identify the definition of an ion.

7.12 Students will identify dissociation as the process which takes place when an ionic electrovalent compound dissolves in water.

7.13 Students will describe the hydration of specified ions.

7.14 To demonstrate knowledge of strong and weak electrolytes, students will:

(1) state the definition of a weak electrolyte or a strong electrolyte; and

(2) identify acetic acid or ammonia water as weak electrolytes.

7.15 To demonstrate knowledge of the ionization of water, students will:

(1) identify the equation for the ionization of water; and

(2) name the two ions produced in the ionization of water.

8.0 Acids, Bases, Salts, pH/Titration.

8.1 To demonstrate knowledge of the nature of acids students will:

(1) identify a common structural characteristic of acids that they contribute one or more hydrogen ions to solution when they are ionized in water; and

*(2) identify the hydronium ion as the ion formed when water takes on a proton.

8.2 To demonstrate knowledge of weak and strong acids, students will:

(1) state the difference between a strong acid and a weak acid;

(2) identify the ionic formula which represents a solution of a specified strong acid;

(3) identify the statement that strong acids are strong electrolytes; and

(4) identify the equation for the ionization of a specified strong acid in water and a specified weak acid in water.

*8.3 Students will identify the Bronsted definition of an acid.

8.4 To demonstrate knowledge of properties and reactions of acids, students will:

+(1) prepare acids and observe their properties using laboratory methods;

(2) list four properties common to all acids; and

(3) write a molecular equation for the reaction between an acid and a metal.

8.5 Students will identify the water solutions of Group I and II metals as bases.

8.6 Students will identify the difference between a strong base and a weak base.

*8.7 Students will identify the Bronsted definition of a base.

8.8 To demonstrate knowledge of properties and reactions of hydroxides, students will:

+(1) prepare metallic hydroxides and observe their properties using laboratory methods;

(2) identify four properties of metallic hydroxides/bases; and

(3) identify the effect that acids and bases have on litmus and on phenolphthalein.

8.9 Students will identify the definition of salt and the statement that all salts are electrovalent compounds.

8.10 Students will identify the balanced net ionic equation for an acid-base reaction.

8.11 Students will identify the definition of molarity.

8.12 Students will identify the definition of a gram equivalent weight and the definition of normality.

*8.13 Students will identify the pH range of an acidic or basic solution.

8.14 Students will identify the definition of titration.

8.15 To demonstrate problem solving ability involving solution concentration, students will:

*(1) calculate the molarity of a solution containing a specified amount of solute in a specified volume of solution, or the mass in grams of a specified solute required to make a specified volume of solution of a specified molarity;

(2) calculate the gram equivalent weight of a specified compound;

(3) calculate the normality of a specified weight of solute dissolved in a specified volume of solution, and calculate the number of grams of a specified solute which would be needed in a specified volume of solution to make a solution of specified normality;

(4) calculate the normality of a basic solution of unknown concentration given the normality and volume of a specified acid required to react with a specified volume of base; and

+(5) determine the concentration of a basic solution by titration.

9.0 Chemical Cells

9.1 Students will identify the element which undergoes oxidation and reduction in a specified chemical equation.

9.2 Students will balance an oxidation-reduction equation using a redox method.

9.3 Students will identify the oxidizing and reducing agents in a specified chemical equation.

9.4 To demonstrate knowledge of electrochemical cells, students will:

(1) identify the definition of an electrochemical cell; and

(2) draw and label a diagram showing how a dry cell battery produces electricity.

9.5 To demonstrate knowledge of electrolytic cells, students will:

(1) define an electrolytic cell;

(2) identify the definition of electrolysis; and

(3) draw and label a diagram showing the electrolysis of water.

9.6 Students will write a general description of a twelve-volt automobile battery.

10.0 Nuclear Reactions

10.1 Students will identify the definition of radioactivity.

10.2 Students will list five properties of radioactive substances.

10.3 Students will identify a definition for alpha, beta, and gamma radiation.

10.4 To demonstrate knowledge of decay of atoms and half-life, students will:

(1) identify the statement that radioactive decay of atoms results in loss of mass and production of energy,

(2) identify the definition of half-life, and

(3) describe the radioactive decay of $^{238}_{92}U$ to $^{234}_{90}Th$.

10.5 Students will state the difference between natural and artificial radioactivity.

10.6 Students will identify the statement that the particle produced when a radioactive nucleus releases an alpha particle is more stable.

10.7 Students will identify the cyclotron as an instrument used for atomic particle acceleration.

10.8 Students will identify the definition of transuranium elements.

10.9 Students will describe in writing the fission of $^{238}_{92}U$.

10.10 Students will identify the definition and give an example of fusion reaction.

10.11 Students will identify reasons for nuclear power as an alternative energy source being a controversial issue in today's society.

Performance Objective		Instructional Implications		Resources	
Number	Topic	Teaching Time	Tested on	County Adopted	Supplementary
1.0	Measurement/ Classification of Matter	1-2 weeks	MLST	H. C. Metcalfe, et al, Modern Chemistry (New York: Holt, Rinehart and Winston, 1978). 1-38	
2.0	Structure of Matter	3-4 weeks	MLST	41-68	
3.0	Periodic Table/ Chemical Bonding	5-6 weeks	MLST	71-117	
4.0	Nomenclature/ Chemical Equations/ Stoichiometry	5-6 weeks	MLST	121-63	
5.0	Gases/The Gas Laws	3-4 weeks	MLST	187-222	
6.0	Liquids/ Solids/ Water	2 weeks	MLST	225-45	

KEY TO RECOMMENDED INSTRUCTIONAL MATERIALS

Performance Objective		Instructional Implications		Resources	
Number	Topic	Teaching Time	Tested on	County Adopted	Supplementary
7.0	Solution Process/ Ionization	3-4 weeks	MLST	249-91	
8.0	Acids/Bases Salts/pH/ Titration	3-4 weeks	MLST	293-346	
9.0	Chemical Cells			469-92	
10.0	Nuclear Reactions			591-609	

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KEY TO LABORATORY RESOURCES

[illegible], and Testa, Laboratory Experiments in Chemistry (New York: Holt, Rinehart and Winston, 1978).

Objective	Skill	County Adopted Text Pages	Other Resources
	Students will:		
+1.4.1	classify elements, compounds and mixtures.	Experiment 6	
+2.5.2	calculate moles from grams.		Ferguson, et al, Laboratory Investigations in Chemistry (Morristown, New Jersey: Silver Burdett, 1978). Experiment 15
+2.7.2	identify metal salt by flame tests.	Experiment 10	
+3.6.4	make molecular models.	Experiment 12	
+4.3.3	determine percentage O_2 in $KClO_3$.	Experiment 13	
+4.7.1	identify types of reactions.	Experiment 16	
+5.12.2	determine molar volume.		Ferguson, et al, Laboratory Investigations in Chemistry (Morristown, New Jersey: Silver Burdett, 1973). Experiment 10

KEY TO LABORATORY RESOURCES

Objective	Skill	County Adopted Text Pages	Other Resources
	Students will:		
+6.8.2	identify physical and chemical properties of water.	Experiment 22	
+7.4.2	observe selectivity of solvents.	Experiment 24	
+8.4.1	prepare acids and observe properties.	Experiment 28 a	
+8.8.1	prepare metallic hydroxides and observe properties.	Experiment 28 b	
+8.15.5	titrate a strong acid and strong base.	Experiment 32	

INTRODUCTION
CHEMISTRY I, ADVANCED

State Accreditator Number. . 1316
Course Code Number 2402
F.T.E. Category. 1.10
Instructional Level. . . . . Advanced

Report Card Abbreviation . . Chem I, Adv
Length of Course . . . . . Year
Credit . . . . . 1 Science credit
Grade Level. 10, 11, 12

Prerequisites

Algebra I with C or better; completed or taking Algebra II or Geometry

Textbook(s)

Metcalfe, H.C., et al, Modern Chemistry (New York: Holt, Rinehart, and Winston, 1978).

Notes to Teachers

Changes have been made in the content and format of the Course Outline and in the Performance Objectives for Chemistry I, Advanced. Full objectives are now included in addition to the Minimum Level Skills (MLS) objectives. Students are to develop laboratory skills as well as content knowledge.

The MLS objectives are indicated with an asterisk (*) and will be the only objectives tested on the Minimum Level Skills Test (MLST). The Chemistry I, Advanced MLST will be field tested this year. The "Teaching Time" listed on the Key to Instructional Materials is a suggested maximum time for each objective to help insure that all MLS objectives can be met by MLST time.

Laboratory skills are indicated with a plus sign (+). Suggested resources for teaching the laboratory skills have been listed at the end of this section of the teacher's guide. Other resources may be substituted for or added to the suggested laboratory resources.

In addition to passing the Minimum Level Skills Test, every student in this course is required to complete and present orally, at least one of the following:

A. Extensive library research

B. Laboratory experimentation

C. Extensive field study or observation

The topic to be investigated may be assigned by the teacher or selected by the student, with teacher approval. This requirement will count at least 1/4 of the grade for the third nine-week grading period. It is recommended that progress be evaluated at least once during each grading period in the first semester to insure that students are proceeding and not procrastinating.

Minimum requirements are suggested as follows:

A. A minimum of 50 hours should be spent in library research, in the field, or in the laboratory.

B. Weekly contact should be maintained between teacher and student regarding progress; students may not contact local agency personnel without teacher assistance and approval.

C. If an extensive library research project is undertaken, students will keep note cards and organize them using an outline. An abstract and bibliography, as well as the note cards and outline, are to be turned in at the time of the oral report.

D. If a laboratory or field study project is done, students will keep a log which will include established and approved procedures and data with conclusions. An abstract and bibliography as well as the log are to be turned in at the time of the oral report.

E. The abstract, outline, and bibliography are to be typed, double spaced. Warriner's English Grammar and Composition: Complete Course, Harcourt, 1977, may be used as a reference.

A guide for each requirement follows:

A. Note Cards (Required for Library Research Project)

As information is gathered, it is to be recorded on index cards. No information should be used in the project which is not on a note card. The student should keep three basic guidelines in mind: (1) no more than one main idea should be recorded on one card; (2) the source of the information, including page numbers, must be on the card; and (3) if the information is quoted directly, quotation marks must be used. The note cards can be shuffled and rearranged as the order of the project content is organized.

B. Log (Required for Laboratory or Field Project)

During investigative experimentation or field study, a dated account of all efforts made during the research, experimentation, observation, or field study is to be kept. It should be noted that a field study with a log constitutes more than a collection with classifications. In an experimental log all data should be recorded and a conclusion or conclusions should be included.

C. Bibliography (Required for All Projects)

The working bibliography is a listing, in the proper bibliographic form, of possible sources of information for the project. It is recommended that this product be done on note cards, with each entry on a separate card. It might be helpful to the student to include the location of each source (school media center, Haydon Burns Library, etc.) on each card. A minimum of ten sources is recommended, of which no more than three may be encyclopedias and at least two of which must be non-book sources (periodicals, pamphlets, audio-visual, interview, etc.). If an additional source is found after the working bibliography is submitted, that source should be approved by the teacher. The final bibliography should be submitted on paper, not note cards.

D. Abstract (Required for All Projects)

An abstract is a summary of the student's project. It is 150-200 words in length. It includes brief statements about what was done, how it was done, what was learned, limitations, and applications of the project.

E. Presentation (Required for All Projects)

The results of every student's project must be presented to an advanced class, entered in the school science fair, or other appropriate presentations. The class presentation should be a minimum of ten minutes and accompanied by visual aids (e.g., posters, films, slides, filmstrips, summary sheet, or chalkboard). These visuals should contain charts, diagrams, or graphs.

Students and teachers desiring further involvement in scientific research should use Performance Objective 13.0 as a guide.

CHEMISTRY I, ADVANCED

1.0 Measurement/Classification of Matter

- 1.1 Metric System
  - 1.1.1 Prefixes
  - +1.1.2 Measurement: mass, volume, density
  - 1.1.3 Metric conversions
- 1.2 Heat/Temperature/Calorie
- 1.3 Scientific Notation/ Significant Figures
  - *1.3.1 Scientific notation
  - 1.3.2 Significant figures
- 1.4 Elements/Compounds/ Mixtures
  - 1.4.1 Differences
  - *1.4.2 Compound identification
  - 1.4.3 Elements: names, symbols
  - *1.4.4 Elements: two classes
  - *1.4.5 States of matter
  - 1.4.6 Law of Definite Composition
  - 1.4.7 Physical/Chemical properties
  - +1.4.8 Observation: physical/chemical changes
  - *1.4.9 Chemical change
  - *1.4.10 Energy changes
- *1.5 Entropy

2.0 Structure of Matter

- 2.1 Atoms/Their Properties
  - 2.1.1 Nucleus / energy levels
  - *2.1.2 Protons / neutrons/ electrons
  - *2.1.3 Charges of atoms
- 2.2 Isotopes/Nuclides
  - 2.2.1 Definitions
  - *2.2.2 Hydrogen
  - 2.2.3 Physical differences
- 2.3 Atomic Number/Mass Number
  - 2.3.1 Definitions
  - *2.3.2 Determination
- 2.4 Mole Concept Calculations
  - *2.4.1 Molecules/Mole
  - 2.4.2 Gram atomic weight
  - 2.4.3 Moles from grams
  - +2.4.4 Moles from lab data
- *2.5 The Photon
- 2.6 Spectra of Atoms
  - +2.6.1 Flame tests
  - 2.6.2 Bright line spectrum
- 2.7 Electron Cloud
- 2.8 Quantum Numbers
  - 2.8.1 Types/Definitions
  - *2.8.2 Energy level number
- 2.9 Electron Arrangement in Atoms
  - 2.9.1 Maximum number per energy level
  - *2.9.2 Electron configuration
  - *2.9.3 Electron dot notation

3.0 The Periodic Table/Chemical Bonding

- 3.1 Arrangement of Periodic Table
  - *3.1.1 Periodic Law
  - 3.1.2 Groups/Periods
  - *3.1.3 Metalloids, transition/rare earth elements

* Indicates Minimum Level Skills
\+ Indicates Laboratory Skills

CHEMISTRY I, ADVANCED

- 3.2 Use of Periodic Table
  - *3.2.1 Groups: chemical properties
  - *3.2.2 Series: metallic, nonmetallic
  - 3.2.3 Atomic radius
  - *3.2.4 Ionization energy
  - 3.2.5 Electron affinity
- 3.3 Chemical Bonding
  - *3.3.1 Valence electrons
  - 3.3.2 Ions/Molecules
- 3.4 Oxidation/Reduction
  - *3.4.1 Formula: ion product
  - 3.4.2 Oxidation numbers: rules
  - *3.4.3 Ternary compounds
- 3.5 Electron Dot Formulas: Binary Compounds
  - *3.5.1 Covalent
  - 3.5.2 Ionic
- 3.6 Electronegativity
  - 3.6.1 Definition
  - *3.6.2 Type bond
  - *3.6.3 Atom holding shared electrons most closely
  - 3.6.4 Polar covalent
  - 3.6.5 Diatomic
  - 3.6.6 Construction of molecular models

4.0 Nomenclature/Chemical Equations/ Stoichiometry

- *4.1 Common Ions: Formulas/ Charges
- 4.2 Formulas: Writing/Naming
  - 4.2.1 Compounds
  - *4.2.2 Stock system
  - 4.2.3 Old system
  - *4.2.4 Greek prefixes
- 4.3 Chemical Formulas: Calculations
  - *4.3.1 Molecular/Formula weight
  - *4.3.2 Percentage composition
  - +4.3.3 Lab investigation: percentage composition
  - *4.3.4 Empirical formula
  - *4.3.5 Molecular formula
- 4.4 Mole/Gram Molecular Weight
  - 4.4.1 Relationship
  - *4.4.2 Moles from grams
- *4.5 Balanced Chemical Equations
- 4.6 Chemical Reactions: Types
  - *4.6.1 Identification
  - +4.6.2 Equations from observation
  - 4.6.3 Equations: reactants/products specified
- *4.7 Activity Series
- *4.8 Stoichiometry
  - 4.8.1 Mole-mole
  - 4.8.2 Grams-moles
  - 4.8.3 Grams-grams

5.0 Gases/The Gas Laws

- 5.1 Kinetic theory
- *5.2 Properties of gases
- 5.3 Gases/Kinetic Theory
  - 5.3.1 Relationship
  - 5.3.2 Ideal gas
  - 5.3.3 Kinetic energy/ Speed

CHEMISTRY I, ADVANCED

- 5.4 Attractive Forces Between Molecules
  - 5.4.1 Condensation temperature
  - 5.4.2 Condensation temperature/ attractive forces
  - *5.4.3 van der Waals forces
  - 5.4.4 Conditions when significant
- *5.5 Variations in Volume
- *5.6 Standard Conditions
- 5.7 Celsius to Kelvin
- 5.8 Boyle's/Charles' Laws
- 5.9 Dalton's Law of Partial Pressure
- 5.10 Avogadro's Principle
- *5.11 Molar Volume/Density
- +5.12 Observation
- 5.13 Calculations
  - 5.13.1 Boyle's Law
  - 5.13.2 Charles' Law
  - *5.13.3 Dry gas
  - *5.13.4 Combined gas laws
  - *5.13.5 Density
  - *5.13.6 Volume-volume
  - *5.13.7 Volume-mass

6.0 Liquids/Solids/Water

- 6.1 Properties: Liquids/ Solids
- 6.2 Liquids/Kinetic Theory
- 6.3 LeChatelier/Physical Equilibrium
  - 6.3.1 Definition: physical equilibrium
  - 6.3.2 Definition: LeChatelier's Principle
  - *6.3.3 Equilibrium/Heat
  - *6.3.4 Reactants/Products
- *6.4 Boiling Point: Liquid
- 6.5 Liquefaction of Gases
- 6.6 Critical Temperature
- 6.7 Kinetic Theory: Liquids/ Solids
- 6.8 Sublimation
- 6.9 Amorphous/Crystalline
- *6.10 Binding Force
- 6.11 Properties of Water
  - +6.11.1 Observation
  - *6.11.2 Change of phase
  - *6.11.3 Chemical stability
  - *6.11.4 Structural formula
- 6.12 Hydrogen Bonding
  - 6.12.1 Definition
  - *6.12.2 Example
  - 6.12.3 Description

7.0 Solution Process/Ionization

- 7.1 Solution Components/ Suspensions
  - *7.1.1 Solute
  - 7.1.2 Solution definition
  - *7.1.3 Most common solvent
  - 7.1.4 Solution/ Suspension
- 7.2 Electrolytes/ Nonelectrolytes
  - 7.2.1 Definitions
  - 7.2.2 Ions/Molecules
- 7.3 Types of Solutions
- 7.4 Selectivity of Solvents
  - *7.4.1 Like dissolves like
  - +7.4.2 Observations
  - 7.4.3 Ethanol
- *7.5 Solution at Equilibrium
- 7.6 Temperature/Pressure
- 7.7 Solution Concentration
  - 7.7.1 Difference between solution/ concentrated solution
  - 7.7.2 One molal

CHEMISTRY I, ADVANCED

- 7.8 Calculations
  - 7.8.1 Molality
  - 7.8.2 Mass of solute
  - 7.8.3 Freezing/Boiling points
- 7.9 Electrolytes/ Nonelectrolytes
- *7.10 Dissociation
- 7.11 Ionization
  - 7.11.1 Modern theory
  - *7.11.2 Ion
- 7.12 Strong Electrolytes/ Weak Electrolytes
  - 7.12.1 Differences
  - 7.12.2 Ionization equation
  - 7.12.3 Dissociation equation
  - *7.12.4 Identification
- 7.13 Ionization of Water

8.0 Acids/Bases/Salts/pH/Titration

- 8.1 Acids
  - 8.1.1 Strong/Weak
  - *8.1.2 Identification
  - *8.1.3 Bronsted acid
  - *8.1.4 Hydronium ion
  - 8.1.5 Formula for hydronium ion
  - 8.1.6 Naming acids
- 8.2 Properties/Reactions of Acids
  - +8.2.1 Observations
  - 8.2.2 Properties
  - 8.2.3 Acid/Metal
  - *8.2.4 Acids as products
- 8.3 Hydroxides/Bases
  - *8.3.1 Identification
  - 8.3.2 Bronsted base
- 8.4 Properties/Reactions: Hydroxides
  - +8.4.1 Observations
  - 8.4.2 Properties
  - 8.4.3 Basic anhydrides
  - 8.4.4 Amphoteric base
- 8.5 Conjugate Acids/ Conjugate Bases
  - 8.5.1 Definitions
  - 8.5.2 Identification
- 8.6 Salts
  - *8.6.1 Definition
  - 8.6.2 Type bonding
  - 8.6.3 Acid/Base reaction
  - 8.6.4 Ionic equation
  - 8.6.5 Neutralization
- 8.7 Molarity
- 8.8 Gram Equivalent Weight/ Normality
- 8.9 Ion Concentration/Pure Water
  - 8.9.1 Hydroxide/Hydronium ions
  - 8.9.2 Neutrality
  - 8.9.3 pH definition
  - 8.9.4 pH equation
- 8.10 Titrations/Indicators
  - 8.10.1 Acid-Base titration
  - +8.10.2 Litmus/ Phenolphthalein
- 8.11 Calculations
  - *8.11.1 Molarity
  - *8.11.2 Mass/Molarity
  - 8.11.3 Gram equivalent weight
  - 8.11.4 Mass/Normality
  - 8.11.5 Normality
  - 8.11.6 Titration
  - *8.11.7 pH
  - 8.11.8 H_3O^+ concentration
  - 8.11.9 OH^- concentration

9.0 Chemical Cells

- 9.1 Oxidation/ Reduction
- 9.2 Oxidation/Reduction Equations
- 9.3 Oxidizing/Reducing Agents
- 9.4 Electrochemical Cells
  - 9.4.1 Definition
  - 9.4.2 Dry cell battery

CHEMISTRY I, ADVANCED

- 9.5 Electrolytic Cells
  - 9.5.1 Definition
  - 9.5.2 Electrolysis
  - 9.5.3 Electroplating
- 9.6 Lead Storage Battery
- 9.7 Voltaic Cell
  - 9.7.1 Description
  - 9.7.2 Zinc-copper

10.0 Nuclear Reactions

- 10.1 Natural Radioactivity
- 10.2 Properties of Radioactive Substances
- 10.3 Nature of Radiation
- 10.4 Transmutation
- 10.5 Atomic Decay / Half-life
  - 10.5.1 Decay of $^{238}_{92}U$ to $^{234}_{91}P$
  - 10.5.2 Definition of half-life
  - 10.5.3 Carbon dating
- 10.6 Artificial Radioactivity
  - 10.6.1 Nuclear mass defect/Binding energy
  - 10.6.2 Stable nuclei
- 10.7 Nuclear Stability/ Radioactive Decay
- 10.8 Proof of Einstein's Equation
- 10.9 The Cyclotron
- 10.10 Transuranium Elements
- 10.11 Fission/Fusion
  - 10.11.1 Describe fission
  - 10.11.2 Define fusion
  - 10.11.3 Nuclear power: advantages, disadvantages

PERFORMANCE OBJECTIVES

To demonstrate the ability to recall and apply knowledge of measurement and classification of matter; the structure of matter; the Periodic Table and chemical bonding; nomenclature, chemical equations, and stoichiometry; gases and the gas laws; liquids, solids, and water; solution process and ionization; and acids, bases, salts, pH, and titration; students will master the performance objectives listed below. Successful completion of Chemistry I Advanced is based on teacher judgement and the requirement that students pass the Minimum Level Skills Test.

Performance Objectives

1.0 Measurement/Classification of Matter

1.1 To demonstrate knowledge of the metric system, students will:

(1) identify the meaning of the prefixes deci-, centi-, milli-, and kilo-;

+(2) use metric apparatus to make measurements in mass, volume, and density; and

(3) convert specified metric units to other specified units within the metric system.

1.2 Students will identify definitions of heat, temperature, and calorie.

1.3 To demonstrate knowledge of scientific notation and significant figures, students will:

*(1) identify the scientific notation for a specified number; and

(2) identify the number of significant figures in a specified number.

1.4 To demonstrate knowledge of elements, compounds, and mixtures, students will:

(1) state the differences between the three classes of matter: elements, compounds, and mixtures;

*(2) identify sugar or water as a compound when given a list of substances;

(3) identify the names and symbols for elements, atomic numbers 1-36;

*(4) identify the two classes of elements as metals and nonmetals;

*(5) identify the states of matter as liquids, solids, and gases;

(6) state the Law of Definite Composition;

(7) identify examples of physical properties and chemical properties;

+(8) identify and distinguish between physical and chemical changes by laboratory methods;

*(9) identify the type of change that occurs when magnesium or copper is heated in air as a chemical change; and

*(10) identify definitions of endothermic and exothermic energy changes.

*1.5 Students will identify a definition of entropy.

2.0 Structure of Matter

2.1 To demonstrate knowledge of the properties of atoms based on the chemical properties of matter students will:

(1) identify the location and charge on the nucleus and energy levels in the atom;

*(2) identify the charge and location of the protons, neutrons, and electrons in an atom; and

*(3) identify the charge on a specified atom of an element is zero when given the number of protons, neutrons, and electrons in that atom.

2.2 To demonstrate knowledge of isotopes and nuclides, students will:

(1) identify definitions of isotope and nuclide;

*(2) identify the three isotopes of hydrogen as protium, deuterium, and tritium; and

(3) describe the physical difference between the three isotopes of hydrogen.

2.3 To demonstrate knowledge of atomic number and mass number, students will:

(1) identify definitions of atomic number and mass number;

*(2) determine the atomic number or mass number of an element when the number of protons, neutrons, and electrons in the atom is specified.

2.4 To demonstrate knowledge of mole concept calculations, students will:

*(1) identify the number of molecules in one mole of a compound as the Avogadro number of molecules;

(2) identify the definition of gram atomic weight;

(3) calculate the number of moles in a specified number of grams of an element; and

+(4) calculate the number of moles of an element from grams of an element using data collected in the laboratory.

*2.5 Students will identify the photon as the unit of energy in which electromagnetic radiation is tranferred to matter.

2.6 To demonstrate knowledge of the spectra of atoms, students will:

+(1) identify a metal salt by the color it gives to a flame using laboratory methods; and

(2) state what the bright line spectrum indicates about the energy emitted from excited hydrogen atoms.

2.7 Students will define electron cloud as an electron path which has a maximum density at the most probable distance of the electron from the nucleus.

2.8 To demonstrate knowledge of quantum numbers, students will:

(1) identify the definitions of principal, orbital, magnetic, and spin quantum numbers; and

*(2) identify the principal quantum number of an electron when given the energy level in which it is found in an atom.

2.9 To demonstrate knowledge of electron arrangement in atoms, students will:

(1) identify the maximum number of electrons that can be found in a specified energy level in an atom;

*(2) identify the correct electron configuration for elements, atomic numbers 1-36;

*(3) identify the electron dot formula for an atom in Groups IA-VIIIA when given the group number for the element.

3.0 The Periodic Table/Chemical Bonding

3.1 To demonstrate knowledge of the arrangement of the Periodic Table, students will:

*(1) identify a statement of the Periodic Law (physical and chemical properties of elements are periodic functions of atomic number);

(2) identify groups or periods on the Periodic Table as vertical or horizontal rows;

*(3) identify the location of the metalloids, transition, and rare earth elements on the Periodic Table.

3.2 To demonstrate the ability to use the Periodic Table, students will:

*(1) identify the statement that elements in the same group have similar chemical properties;

*(2) identify from a list of elements in a specified series the most nonmetallic or metallic element;

(3) identify a specified atom at the end of a period or group as having a smaller or larger atomic radius than a specified atom at the beginning of that period or group;

*(4) identify the element having the lowest ionization energy in a specified group; and

(5) identify the group on the Periodic Table which would have the highest positive electron affinities.

3.3 To demonstrate knowledge of chemical bonding, students will:

*(1) identify the number of valence electrons in a specified element in Groups IA-VIIIA; and

(2) identify ions as the type particle produced by electron transfer or molecules as the type particle produced by electron sharing;

3.4 To demonstrate knowledge of oxidation and reduction, students will:

*(1) identify the formula for the ion in a specified ionic compound which has undergone oxidation or reduction;

(2) use rules for assigning oxidation numbers to determine oxidation numbers of elements in specified compounds; and

*(3) identify the oxidation number of an element in a ternary compound.

3.5 To demonstrate electron dot formulas for binary compounds, students will:

*(1) identify the electron dot formula for a specified binary covalent compound; and

(2) identify the electron dot formula for a specified binary ionic compound.

3.6 To demonstrate knowledge of electronegativity, students will:

(1) state the definition of electronegativity;

*(2) use the Periodic Table of electronegativities to determine the type bond in a binary compound;

*(3) identify the atom in a binary polar covalent compound which holds the shared electrons most closely;

(4) describe the structure of a polar covalent molecule;

(5) identify a specified diatomic molecule as having nonpolar covalent bonding; and

(6) construct molecular models of specified molecules in the laboratory.

4.0 <u>Nomenclature/Chemical Equations/Stoichiometry</u>

*4.1 Students will identify formulas and charges for the common ions.

4.2 To demonstrate knowledge of chemical formula writing and naming compounds, students will:

(1) write chemical formulas for compounds and name compounds;

*(2) identify the name or formula for a compound using the Stock system of nomenclature;

(3) identify the name or formula for a compound using the old system of nomenclature; and

*(4) identify the name or formula of a covalent binary compound of nonmetals using Greek numerical prefixes.

4.3 To demonstrate the ability to perform calculations involving chemical formulas, students will:

*(1) calculate the molecular or formula weight of a specified compound;

*(2) calculate the percentage composition of a specified compound;

+(3) determine the percentage of oxygen in potassium chlorate from data collected in the laboratory;

*(4) calculate the empirical formula for a compound from percentage composition data; and

*(5) calculate the molecular formula for a compound from percentage composition and molecular weight data.

4.4 To demonstrate knowledge of the mole and gram molecular weight, students will:

(1) explain the relationship between the mole and gram molecular weight; and

*(2) calculate the number of moles of a compound in a specified number of grams of a compound.

*4.5 Students will identify by inspection a balanced chemical equation.

4.6 To demonstrate knowledge of the general types of chemical reactions, students will:

*(1) identify from a list of specified reactions the one which is composition, decomposition, replacement, or ionic;

+(2) write chemical equations and identify types of chemical reactions from observations made in the laboratory; and

(3) write balanced chemical equations for reactions when reactants and products are specified.

*4.7 Given an Activity Series Table, students will use the activity series to identify whether a specified metal will replace another specified metal in a given compound.

*4.8 To demonstrate knowledge of stoichiometry, students will:

(1) calculate the number of moles of a substance required to react with a specified number of moles of a second reactant, given a balanced chemical equation;

(2) calculate the number of moles of product using a balanced chemical equation when a specified number of grams of a reactant is placed in the same reacting vessel; and

(3) calculate the weight in grams of a reactant which would be required to react with a specified number of grams of a second reactant.

5.0 Gases/The Gas Laws

5.1 Students will state the three basic assumptions of the kinetic theory of matter.

*5.2 Students will identify characteristic properties of a gas as expansion, pressure, low density and diffusion.

5.3 To demonstrate knowledge of the relationship between gases and the kinetic theory, students will:

(1) describe a gas according to the kinetic theory;

(2) define an ideal gas; and

(3) identify K.E. = $\frac{1}{2}$ mv^2 as the equation which indicates how the kinetic energy of a molecule is related to its speed.

5.4 To demonstrate knowledge of the attractive forces between gaseous molecules, students will:

(1) identify the definition of condensation temperature;

(2) identify a statement describing the relationship between condensation temperature and the strength of attractive forces between gaseous molecules;

*(3) identify van der Waals forces as the only type of attractive force between nonpolar covalent molecules; and

(4) identify the statement that van der Waals forces become significant between real nonpolar gaseous molecules at low temperature and high pressure.

*5.5 Students will identify a statement describing how the volume of a gas varies with specified temperature and pressure changes.

*5.6 Students will identify standard temperature in Celsius degrees and standard pressure in mm mercury.

5.7 Students will convert a specified Celsius temperature to a Kelvin temperature.

5.8 Students will state Boyle's Law and Charles' Law.

5.9 Students will identify a statement of Dalton's Law of Partial Pressure.

5.10 Students will state Avogardro's principle.

*5.11 Students will identify definitions of molar volume and density.

+5.12 Students will observe hydrogen displacement by magnesium in the laboratory.

5.13 To demonstrate knowledge of problem solving involving gases, students will:

(1) calculate the volume of a gas at standard pressure when a volume is given at a specified pressure using Boyle's Law;

(2) calculate the volume of a gas at standard temperature when given a volume at a specified temperature using Charles' Law;

*(3) calculate the volume of a gas at STP when given a volume at a temperature and pressure other than standard using Boyle's and Charles' Laws combined;

(4) calculate the volume of a dry gas at STP when given a volume at a temperature and pressure other than standard using Boyle's and Charles' Laws combined and water vapor pressure;

*(5) calculate the density of a specified gas at STP;

*(6) calculate the liters of a gas produced at STP from the number of liters of a gaseous reactant at STP given a chemical equation; and

*(7) calculate the volume of a gas produced at STP using a chemical equation when given a specified number of grams of a reactant.

6.0 Liquids/Solids/Water

6.1 Students will state four properties of liquids and of solids.

6.2 Students will describe a liquid according to the kinetic theory.

6.3 To demonstrate knowledge of LeChatelier's principle and physical equilibrium, students will:

(1) state the definition for physical equilibrium;

(2) state LeChatelier's principle;

*(3) identify the direction that a liquid-vapor equilibrium will shift as heat is added to or removed from the system; and

*(4) identify the statement that amounts of reactants and products in a chemical system at equilibrium will remain unchanged.

*6.4 Students will identify the definition of the boiling point of a liquid.

6.5 Students will state two steps required to liquefy a gas.

6.6 Students will define critical temperature of a gas.

6.7 Students will list ways by which liquids and solids conform to the kinetic theory.

6.8 Students will define sublimation.

6.9 Students will compare the particle arrangement in amorphous solids with the particle arrangement in crystalline solids.

*6.10 Students will identify the type of binding force in a specified crystal of sodium chloride or diamond.

6.11 To demonstrate knowledge of the properties of water, students will:

+(1) observe chemical properties of water using laboratory procedures;

*(2) identify the line which represents the freezing phase or boiling phase on a diagram representing the changes of phase of water;

*(3) identify the chemical stability of water as very stable; and

*(4) identify the structural formula for the water molecule.

6.12 To demonstrate knowledge of hydrogen bonding, students will:

(1) define hydrogen bonding;

*(2) identify water as a substance which exhibits hydrogen bonding between its molecules; and

(3) describe hydrogen bonding as it occurs in water.

7.0 Solution Process/Ionization

7.1 To demonstrate knowledge of solute, solvent, solutions and suspensions, students will:

*(1) identify the solute in a specified solution;

(2) identify the definition of a solution;

*(3) identify water as the most common solvent; and

(4) describe the difference between a solution and a suspension.

7.2 To demonstrate knowledge of electrolytes and nonelectrolytes, students will:

(1) define electrolyte or nonelectrolyte; and

(2) identify the statement that most electrolytes are made up of ions or that most nonelectrolytes are made up of molecules.

7.3 Students will identify the type of a specified example of a solution.

7.4 To demonstrate knowledge of selectivity of solvents, students will:

*(1) identify the statement, "Like dissolves like," as a reason that two specified substances are mutually soluble;

+(2) observe the selectivity of solvents in the laboratory; and

(3) explain why ethanol is capable of dissolving both polar and nonpolar substances.

*7.5 Students will identify the description of a specified solution at equilibrium as a solution which is saturated.

7.6 Students will identify how the solubility of a solid in a liquid and the solubility of a gas in a liquid is affected by temperature and pressure changes.

7.7 To demonstrate knowledge of solution concentration, students will:

(1) state the difference between a solution and a concentrated solution; and

(2) identify the definition of a one molal solution.

7.8 To demonstrate knowledge of problem solving involving solutions, students will:

(1) calculate the molality of a solution when the mass of solute and mass of solvent are specified;

(2) calculate the weight in grams of a specified solute required to make a solution of specified molality; and

(3) calculate the freezing point or boiling point of a solution of a nonelectrolyte when the mass of the solute, mass of the solvent, and molal freezing point depression or molal boiling point elevation are given.

7.9 Students will explain why solutions of electrolytes will conduct an electric current and solutions of nonelectrolytes will not conduct electricity.

*7.10 Students will identify dissociation as the process which takes place when a specified ionic compound dissolves in water.

7.11 To demonstrate knowledge of ionization, students will:

(1) state the three basic assumptions of the modern theory of ionization; and

*(2) identify the definition of an ion.

7.12 To demonstrate knowledge of strong and weak electrolytes, students will:

(1) identify the differences between strong and weak electrolytes;

(2) write the equation for the ionization of acetic acid, hydrogen chloride, or ammonia in water solution;

(3) write the equation for the dissociation of an ionic compound in water solution; and

*(4) given a list of electrolyte solutions, NaCl, HCl, KOH, $HC_2H_3O_2$, identify the one which contains the least number of ions.

7.13 Students will write the chemical equation for the ionization of water.

8.0 Acids/Bases/Salts/pH/Titration

8.1 To demonstrate knowledge of acids, students will:

(1) state the difference between strong and weak acids;

*(2) identify the strongest and the weakest acids from the following list: H_2SO_4, $HC_2H_3O_2$, HNO_3, HCl;

*(3) identify the Bronsted definition of an acid;

*(4) identify the hydronium ion as the positive ion produced when an acid transfers a proton in water solution;

(5) identify the formula for the hydronium ion; and

(6) name the following acids from their formulas: HCl, H_2SO_4, H_2SO_3, HNO_3, HNO_2, $HC_2H_3O_2$.

8.2 To demonstrate knowledge of properties and reactions of acids, students will:

+(1) prepare acids and observe their properties using laboratory methods;

(2) list four properties common to all acids;

(3) write the molecular equation for the reaction between an acid and a metal; and

*(4) identify acids as products of reactions between specified nonmetallic oxides/acid anhydrides and water.

8.3 To demonstrate knowledge of hydroxides and bases, students will:

*(1) identify a specified hydroxide of a Group IA or IIA metal as a base; and

(2) identify the Bronsted definition of a base.

8.4 To demonstrate knowledge of properties and reactions of hydroxides, students will:

+(1) prepare metallic hydroxides and observe their properties using laboratory methods;

(2) list four properties of metallic hydroxides;

(3) identify oxides of active metals that react with water as basic anhydrides; and

(4) identify the definition of amphoteric and give an example of an amphoteric base.

8.5 To demonstrate knowledge of conjugate acids and conjugate bases, students will:

(1) identify definitions of conjugate acid and conjugate base; and

(2) identify the conjugate acid or conjugate base of a specified acid or base in a specified equation.

8.6 To demonstrate knowledge of salts, students will:

*(1) identify the definition of a salt;

(2) identify the type bonding in salts;

(3) write the molecular equation for a specified salt producing reaction between an acid and a base;

(4) identify the net ionic equation for a reaction between a strong acid and a metallic hydroxide as: $H_3O^+ + OH^- \rightleftharpoons 2\ H_2O$; and

(5) describe the process of neutralization.

8.7 Students will identify the definition of molarity.

8.8 Students will state the definition of equivalent weight and normality.

8.9 To demonstrate knowledge of ion concentration in pure water, students will:

(1) identify the concentration of the hydroxide and hydronium ions in pure water at 25°C as 1×10^{-7} mole/l;

(2) state the reason that pure water is neutral;

(3) identify the definition of pH; and

(4) write a mathematical equation for pH.

8.10 To demonstrate knowledge of titrations and indicators, students will:

(1) identify the definition of an acid-base titration; and

+(2) identify the effect of acids and bases on litmus and phenolphthalein.

8.11 To demonstrate knowledge of calculations involving molarity, equivalent weight, normality, titration, pH, and OH^- and H_3O concentration, students will:

*(1) calculate the molarity of a solution containing a specified amount of solute in a specified volume of solution;

*(2) calculate the number of grams of a specified compound required for a solution of specified molarity;

(3) calculate the gram equivalent weight of a specified compound;

(4) calculate the number of grams of a compound needed in a specified volume of solution to make a solution of specified normality;

(5) calculate the normality of a solution containing a specified amount of solute in a specified volume of solution;

(6) calculate the concentration of a base when the normality of the acid, volume of the acid, and the volume of the base are known;

*(7) calculate the pH of a strong acid or basic solution when given the concentration of the solutions, without logarithms;

(8) calculate the hydronium ion concentration in a strong acid of specified concentration; and

(9) calculate the hydroxide ion concentration in a strong base of specified concentration.

9.0 Chemical Cells

9.1 Students will identify the elements which undergo oxidation and reduction in a specified chemical equation.

9.2 Students will balance an oxidation-reduction equation using a redox method.

9.3 Students will identify the oxidizing and reducing agents in a specified chemical equation.

9.4 To demonstrate knowledge of electrochemical cells and the production of electricity, students will:

(1) identify the definition of electrochemical cell; and

(2) draw and label a diagram showing how a dry cell battery produces electricity including the direction of electron flow.

9.5 To demonstrate knowledge of electrolytic cells, students will:

(1) define an electrolytic cell;

(2) draw and label a diagram showing the electrolysis of water including equations for anode and cathode reactions; and

(3) draw and label a diagram showing the electrolytic cell for electroplating using silver nitrate and include anode and cathode reactions.

9.6 Students will write a general description of a lead storage battery.

9.7 To demonstrate knowledge of a voltaic cell, students will:

(1) describe a voltaic cell; and

(2) diagram and label a zinc-copper voltaic cell showing direction of electron flow.

10.0 Nuclear Reactions

10.1 Students will identify the definition of radioactivity.

10.2 Students will list five properties of radioactive substances.

10.3 Students will define and give the symbols for alpha and beta particles and gamma rays.

10.4 Students will identify the definition of transmutation.

10.5 To demonstrate knowledge of half-life and decay, students will:

(1) write a nuclear equation showing the decay of $^{238}_{92}U$ to $^{234}_{91}P$;

(2) identify the definition of half-life; and

(3) describe how the age of certain carbon containing materials can be determined using half-life.

10.6 To demonstrate knowledge of nuclear mass defect, binding energy, and stable nuclei, students will:

(1) identify the definition of nuclear mass defect and binding energy; and

(2) identify the statement that the most stable nuclei are those of elements having intermediate atomic weights.

10.7 Students will identify the statement that the particle produced when a radioactive nucleus emits an alpha particle is more stable than its parent particle.

10.8 Students will describe Cockcroft and Walton's experimental proof of Einstein's equation.

10.9 Students will describe how protons are accelerated in a cyclotron.

10.10 Students will identify the definition of the transuranium elements.

10.11 To demonstrate knowledge of fission, fusion, and the effects of nuclear power, students will:

(1) describe the fission reaction of uranium which takes place in a nuclear reactor;

(2) identify the definition of fusion reaction; and

(3) list some of the advantages and disadvantages of using nuclear eactions to produce electrical power.

KEY TO RECOMMENDED INSTRUCTIONAL MATERIALS

Performance Objective		Instructional Implications		Resources	
Number	Topic	Teaching Time	Tested on	County Adopted Pages	Supplementary
1.0	Measurement/ Classification of Matter	1-2 weeks	MLST	H. C. Metcalfe, J. E. Williams, Modern Chemistry (New York: Holt, Rinehart and Winston, 1978). 1-38	
2.0	Structure of Matter	3-4 weeks	MLST	41-68	
3.0	Periodic Table/ Chemical Bonding	5-6 weeks	MLST	71-117	
4.0	Nomenclature/ Chemical Equations/ Stoichiometry	5-6 weeks	MLST	121-63	
5.0	Gases/The Gas Laws	5-6 weeks	MLST	187-222	

KEY TO RECOMMENDED INSTRUCTIONAL MATERIALS

Performance Objective		Instructional Implications		Resources	
Number	Topic	Teaching Time	Tested on	County Adopted	Supplementary
6.0	Liquids/ Solids/ Water	2 weeks	MLST	225-45	
7.0	Solution Process/ Ionization	3-4 weeks	MLST	249-91	
8.0	Acids/Bases/ Salts/pH/ Titration	3-4 weeks	MLST	293-346	
9.0	Chemical Cells			469-92	
10.0	Nuclear Reactions			591-609	

H. C. Metcalfe, J. E. Williams, J. F. Castka, Laboratory Experiments in Chemistry (New York: Holt, Rinehart and Winston, 1978).

KEY TO LABORATORY RESOURCES

Objective	Skill	County Adopted Text Pages	Other Resources
	Students will:		
+1.1.2	use metric apparatus to make measurements in mass, length, and volume.	10-12	
+1.4.8	observe physical and chemical changes in the lab.	Experiment 7	
+1.6.2	identify specified substance as elements, compounds, or mixtures using laboratory methods.	23-24	
+2.4.4	calculate the number of moles of an element from grams of an element using data collected in the laboratory.		Ferguson, et al. Laboratory Investigations in Chemistry (Morristown, New Jersey: Silver Burdett, 1973). Experiment 15.
+2.6.1	identify a metal salt by the color it gives to a flame.	Experiment 10	

KEY TO LABORATORY RESOURCES

Objective	Skill	County Adopted Text Pages	Other Resources
	Students will:		
+4.3.3	determine the percentage of oxygen in potassium chlorate from data collected in the laboratory.	37-38	
+4.6.2	write chemical equations and identify types of chemical reactions from observations made in the laboratory.	43-46	
+5.12	determine the molar volume of a gas using laboratory methods.		Ferguson, et al, Investigation 10.
+6.11.1	observe chemical and physical properties of water using laboratory procedures.	62-63	
+7.4.2	observe the selectivity of solvents in the laboratory.	67-68	
+8.2.1	prepare acids and observe their properties using laboratory methods.	75-77	

KEY TO LABORATORY RESOURCES

Objective	Skill	County Adopted Text Pages	Other Resources
	Students will:		
+8.4.1	prepare hydroxides and observe their properties using laboratory methods.	Experiment 28 B	
+8.10.2	determine the end point of an acid base reaction using litmus/phenolphthalein.		

INTRODUCTION
CHEMISTRY II, ADVANCED

State Accreditator Number. . 1325
Course Code Number 2410
F.T.E. Category. 1.10
Instructional Level. . . . . Advanced

Report Card Abbreviation . . Chem II Adv
Length of Course . . . . . Year
Credit . . . . . 1 Science credit
Grade Level. 11, 12

Prerequisites

Chemistry I and departmental approval; completed or taking Algebra II

Textbook(s)

Masterton, W. L., et al, Chemical Principles (Philadephia: Saunders College Publishing, 1981).

Notes to Teachers

Full objectives are included for an Advanced Placement Chemistry II course in addition to the Minimum Level Skills (MLS) objectives. Students are to develop laboratory skills as well as content knowledge.

The MLS objectives are indicated with an asterisk (*) and will be the only objectives tested on the Minimum Level Skills Test (MLST). The Chemistry II, Advanced MLST will be field tested this year. The "Teaching Time" listed on the Key to Instructional Materials is a suggested maximum time for each objective to help ensure that all MLS objectives can be met by MLST time, and that the additional objectives can be presented, however briefly, before AP test time. The suggestion is made that the amount of time spent on 1.0 and 2.0, Chemistry I review material, be limited as much as possible to allow more time for new material.

Laboratory skills are indicated with a plus sign (+). Essential laboratory activities are indicated with an encircled plus sign (⊕).

Students taking this class should be encouraged to take the Chemistry Advanced Placement test.

CHEMISTRY II, ADVANCED

1.0 Measurement/Atomic Theory/Atomic Structure

- 1.1 Measurement
  - 1.1.1 Prefixes/Abbreviations
  - 1.1.2 Metric units: length, volume, temperature, mass, energy
  - 1.1.3 Metric conversions
  - *1.1.4 Significant figures/Calculated quantities
- 1.2 Elements/Compounds/Mixtures
  - *1.2.1 Differences
  - 1.2.2 Chemical/Physical properties
  - 1.2.3 Identifications
- 1.3 Atomic Theory
  - 1.3.1 Dalton's Atomic Theory
  - 1.3.2 Law of Conservation of Mass
  - 1.3.3 Law of Constant Composition
  - 1.3.4 Law of Multiple Proportions
  - *1.3.5 Calculations: ratio
  - *1.3.6 Calculations: atoms
  - 1.3.7 Avogadro's number/Mole
- 1.4 Atomic Structure
  - 1.4.1 Electron
  - 1.4.2 Nucleus/Protons/Neutrons
  - 1.4.3 Atomic number/Mass number/Atomic mass
  - *1.4.4 Isotopes/Atomic weight
  - 1.4.5 Ions

2.0 Chemical Formulas/Chemical Equations/Stoichiometry

- 2.1 Chemical Formulas: Empirical/Molecular
  - 2.1.1 Compound names
  - *2.1.2 Formula writing
  - 2.1.3 Percent composition
  - 2.1.4 Empirical formula
  - *2.1.5 Molecular formula
  - ●2.1.6 Hydrate formula determination
- 2.2 Chemical Equations/Stoichiometry
  - 2.2.1 Chemical equations: writing
  - *2.2.2 Chemical equations: balancing
  - *2.2.3 Stoichiometry
  - 2.2.4 Limiting reagent
  - ●2.2.5 Mass, mole determination

3.0 Electron: Energies/Arrangement/Periodic Table

- 3.1 Electron Energies
  - 3.1.1 Electron energy factors
  - *3.1.2 Ground/Excited state
  - 3.1.3 $E = \frac{hc}{\lambda}$
  - 3.1.4 Bohr model
  - 3.1.5 Electron energy calculation
  - +3.1.6 Hydrogen: atomic spectrum
- 3.2 Quantum Mechanical Theory
  - 3.2.1 deBroglie relationship
  - 3.2.2 Schrodinger Wave Equation
  - 3.2.3 Quantum numbers: n, l, m, s
  - 3.2.4 Quantum numbers: specific elements

* Indicates Minimum Level Skills
\+ Indicates Recommended Laboratory Activities
● Indicates Essential Laboratory Activities

COURSE OUTLINE

CHEMISTRY II, ADVANCED

- 3.2.5 Pauli's Exclusion Principle
- 3.2.6 Electron configuration/ Orbital diagram
- 3.2.7 Hund's Rule
- *3.2.8 Unpaired electrons
- 3.2.9 Magnetic properties: prediction

3.3 Periodic Table
- 3.3.1 Structure
- *3.3.2 Location/Electron configuration
- 3.3.3 Relative values: prediction
- 3.3.4 Ionization energies
- *3.3.5 Atomic radius
- *3.3.6 Physical properties: prediction
- 3.3.7 Oxidation numbers

4.0 Chemical Bonding/Molecular Geometry

4.1 Ionic Compounds
- 4.1.1 Description/ Examples
- 4.1.2 Lewis dot formula

4.2 Covalent Bonds
- 4.2.1 Description/ Examples
- *4.2.2 Bond polarity
- 4.2.3 Bond length
- 4.2.4 Bond energies
- 4.2.5 Bonds: sigma, pi

4.3 Molecular Geometry
- 4.3.1 Lewis structures: molecules, ions
- *4.3.2 Hybridization prediction
- *4.3.3 Shape prediction
- 4.3.4 Dipole moment prediction
- 4.3.5 Lewis structures: resonance compounds
- 4.3.6 Formal charge
- 4.3.7 Covalent bonding theories
- 4.3.8 Molecular orbital diagram/Bond order
- *4.3.9 Complex ion: formulas, charges
- 4.3.10 Coordination compound bonding theories

5.0 Gases/Liquids/Solids

5.1 Boyle's/Charles' Laws

5.2 Kinetic Theory

5.3 Ideal Gas Law
- 5.3.1 Condition changes
- *5.3.2 Calculation: one variable
- 5.3.3 Calculation: density
- 5.3.4 Calculation: molecular mass
- 5.3.5 Deviations

5.4 Gay-Lussac Combining Volumes

*5.5 Dalton's Law Calculations

5.6 Graham's Law
- 5.6.1 Effusion rates
- 5.6.2 Molecular mass calculation

5.7 Liquids
- 5.7.1 Liquid-vapor equilibrium
- 5.7.2 Boiling point
- 5.7.3 Attractive forces
- 5.7.4 Clausius-Clapeyron equation
- +5.7.5 Molecular mass determination

5.8 Solids
- 5.8.1 Classification
- 5.8.2 Properties
- *5.8.3 Predictions
- 5.8.4 Density calculations

COURSE OUTLINE

CHEMISTRY II, ADVANCED

- 5.9 Phase Changes
  - 5.9.1 Definitions
  - 5.9.2 Diagrams
  - *5.9.3 ΔH calculations

6.0 Solutions

- 6.1 Concentrations
  - 6.1.1 Molarity/Molality/Weight percentage
  - *6.1.2 Mole determination/Molar solution
  - 6.1.3 Mole fraction definition
  - *6.1.4 Mole fraction calculation
- 6.2 Solubility
  - 6.2.1 Solution process
  - 6.2.2 Energy changes
  - *6.2.3 Relative solubilities
  - 6.2.4 Henry's Law
  - 6.2.5 Solubility: temperature, pressure
- 6.3 Raoult's Law
- 6.4 Colligative properties
  - 6.4.1 Definitions
  - *6.4.2 Molecular weight calculations
  - ●6.4.3 Molecular weight determination
  - 6.4.4 Electrolyte differences
- 6.5 Colloids

7.0 Gaseous Equilibria/K_{sp}

- 7.1 Gaseous Equilibria
  - 7.1.1 Equilibrium constant expression
  - *7.1.2 Equilibrium constant calculation
  - 7.1.3 Equilibrium concentrations calculation
  - *7.1.4 Extent of reaction
  - 7.1.5 K_c/K_p
  - 7.1.6 Predictions: non-equilibrium systems
  - 7.1.7 Le Chatelier's Principle: temperature, volume
  - *7.1.8 Le Chatelier's Principle: concentration changes
  - +7.1.9 Equilibrium constant determination
  - 7.1.10 Temperature changes/Equilibrium constant
- 7.2 Solubility Product Constant
  - 7.2.1 Slightly soluble salts: net ionic equations, K_{sp}
  - *7.2.2 K_{sp} expression
  - *7.2.3 Solubility calculations
  - 7.2.4 K_{sp} calculations
  - 7.2.5 Common ion
  - 7.2.6 Precipitation predictions
  - 7.2.7 Multiple precipitates

8.0 Acids/Bases/Salts

- 8.1 Acids/Bases
  - 8.1.1 Theories: Arrhenius/Bronsted-Lowry/Lewis
  - 8.1.2 Properties
  - 8.1.3 Ionic equations
  - 8.1.4 Strong/Weak
  - 8.1.5 Acid strength: ionization

COURSE OUTLINE

CHEMISTRY II, ADVANCED

- 8.1.6 Acid strength: covalent bond
- *8.1.7 Binary acids
- 8.1.8 Oxyacids
- *8.1.9 Conjugate pairs
- 8.1.10 Relative strength chart

8.2 Salts
- 8.2.1 Neutral solution
- *8.2.2 Ionic substance prediction

9.0 Ionic Equilibria

9.1 Acid/Base
- 9.1.1 K_w
- 9.1.2 K_a
- 9.1.3 pK
- 9.1.4 Hydrogen concentration calculations
- *9.1.5 pH calculation
- 9.1.6 Percent ionization calculation
- 9.1.7 Titration graphs
- 9.1.8 Net ionic equations
- *9.1.9 Titration calculation
- +9.1.10 Gram equivalent weight determination
- 9.1.11 Indicators
- *9.1.12 Buffers: hydrogen ion calculation
- 9.1.13 Buffers: pH calculation
- 9.1.14 K_b

9.2 Complex Ions
- 9.2.1 Net ionic equations
- 9.2.2 Dissociation constant expression
- 9.2.3 K_{diss} calculations

9.3 Multiple Equilibria
- 9.3.1 Constants
- 9.3.2 Amphoterism
- #9.3.3 Qualitative analysis

10.0 Oxidation-Reduction/ Electrochemistry

10.1 Oxidation-Reduction
- 10.1.1 Definitions
- 10.1.2 Oxidation number determination
- 10.1.3 Half reactions
- 10.1.4 Balance redox equations
- 10.1.5 Activity Series

10.2 Electrochemistry
- 10.2.1 Definitions
- 10.2.2 Faraday's Law
- 10.2.3 Call notation
- 10.2.4 Electrolytic cell
- 10.2.5 Voltaic cell
- +10.2.6 Equivalent weight determination
- 10.2.7 Relative strengths
- 10.2.8 Cell voltage
- 10.2.9 Spontaneous occurence
- 10.2.10 ΔG^o
- 10.2.11 Nernst equation

11.0 Kinetics/Thermodynamics

11.1 Kinetics
- 11.1.1 Average rate definition
- 11.1.2 Instantaneous rate
- 11.1.3 Rate experession
- 11.1.4 Order of reaction
- 11.1.5 Rate constant/Units
- 11.1.6 Rate equation calculations
- 11.1.7 Factors affecting rate
- +11.1.8 Reaction rate
- 11.1.9 Activation energy definition

CHEMISTRY II, ADVANCED

- 11.1.10 Activation energy diagram
- 11.1.11 Catalysts
- 11.1.12 Arrhenius equation
- 11.1.13 Reaction mechanism

11.2 Thermodynamics

- 11.2.1 Exothermic/ Endothermic reactions
- 11.2.2 Thermochemical equations
- 11.2.3 Hess's Law
- 11.2.4 ΔH calculation: heat formation, bond energies
- +11.2.5 ΔH determination
- 11.2.6 Specific heat
- 11.2.7 Heat capacity
- 11.2.8 Thermodynamics: First Law
- 11.2.9 First Law definitions
- 11.2.10 Internal energy change calculation
- 11.2.11 Free energy/ Entropy
- 11.2.12 Entropy calculations
- 11.2.13 Gibbs-Helmholtz equation
- 11.2.14 Reaction spontaneity
- 11.2.15 Free energy change relationship: equilibrium constant
- 11.2.16 Free energy change relationship: electrode potentials

12.0 Nuclear/Organic Chemistry

12.1 Nuclear Chemistry

- 12.1.1 Radiation types
- 12.1.2 Balanced nuclear reactions
- 12.1.3 Half-life
- 12.1.4 Radiation effects
- 12.1.5 Energy/Mass

12.2 Organic Chemistry

- 12.2.1 Structural formula
- 12.2.2 Physical properties
- 12.2.3 IUPAC naming system
- 12.2.4 Isomers: structural, geometric
- 12.2.5 Functional groups
- 12.2.6 Hydrocarbon reactions

PERFORMANCE OBJECTIVES
CHEMISTRY II, ADVANCED

To demonstrate the ability to apply knowledge of measurement and classification of matter; atomic theory and structure; chemical formulas, equations and stoichiometry; electron energies and arrangement; the Periodic Table; chemical bonding and molecular geometry; gases, liquids, and solids; solutions; gaseous equilibria; the solubility product constant; acids, bases, and salts; ionic equilibria; electrochemistry; kinetics and thermodynamics; and nuclear and organic chemistry, students will master the performance objectives listed below. Successful completion of Chemistry II, Advanced is based on teacher judgment and the requirement that students pass the Minimum Level Skills Test.

Performance Objectives

1.0 Measurement/Atomic Theory/Atomic Structure

1.1 To demonstrate knowledge of measurement, students will:

(1) define prefixes and abbreviations;

(2) measure length, volume, mass, temperature and energy using metric units;

(3) use the conversion factor approach to convert from one unit to another; and

*(4) apply knowledge of significant figures in determining the number of significant digits necessary in a quantity that has been derived from calculations.

1.2 To demonstrate knowledge of elements, compounds, and mixtures, students will:

*(1) differentiate elements from compounds when given a list;

(2) describe the physical and chemical properties of each; and

(3) choose and describe a method which is most appropriate for isolating and identifying a specific substance, when the substance occurs as part of a mixture of substances.

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* Indicates Minimum Level Skills
+ Indicates Recommended Laboratory Activities
● Indicates Essential Laboratory Activities

1.3 To demonstrate comprehension of atomic theory, students will:

(1) summarize Dalton's Atomic Theory;

(2) state the Law of Conservation of Mass;

(3) state the Law of Constant Composition;

(4) state the Law of Multiple Proportions;

*(5) calculate the combining ratio for a specified element in two different compounds when given percent composition data;

*(6) calculate the number of atoms when given the mass in grams of a specified substance and Avogadro's number; and

(7) explain the relationship between Avogadro's number and the mole.

1.4 To demonstrate comprehension of the components of the atom, students will:

(1) summarize the properties of the electron;

(2) summarize the properties of the atomic nucleus, protons, and neutrons;

(3) define atomic number, mass number, and atomic mass;

*(4) calculate the approximate atomic weight of a naturally occurring element from masses and relative abundance of isotopes; and

(5) state properties of ions.

2.0 Chemical Formulas/Chemical Equations/Stoichiometry

2.1 To demonstrate comprehension of empirical and molecular formulas, students will:

(1) name ionic compounds and binary non-metal compounds;

*(2) identify the correct chemical formula when given the name of an ionic compound;

(3) calculate percent composition from a chemical formula;

(4) determine the empirical formula when given the percent composition data;

*(5) determine the molecular formula when given percent composition and molecular mass data; and

●(6) determine the empirical formula of a hydrate from data collected in the laboratory.

2.2 To demonstrate knowledge of chemical equations and stoichiometry, students will:

(1) write chemical equations;

*(2) identify by inspection the coefficients necessary to balance a given chemical equation;

*(3) calculate mass in grams of a reactant which would be required to react with a specified number of grams of a second reactant when given a balanced equation;

(4) determine the limiting reagent in a reaction when given the masses of all reactants; and

●(5) determine mass and mole relationships from data collected in the laboratory.

3.0 Electron: Energies/Arrangement/Periodic Table

3.1 To demonstrate knowledge of electron energies, students will:

(1) list factors determining the energy of an electron in an atom;

*(2) differentiate between a ground state and an excited state of an electron in an atom when given examples of electron configurations;

(3) relate the energy, wave length, and frequency using the equations, $E = hf$ and $E = \frac{hc}{\lambda}$;

(4) discuss the Bohr model for the hydrogen atom;

(5) calculate the energy of an electron in a given principal energy level of the hydrogen atom and the difference in energy between two levels; and

+(6) analyze the atomic spectrum of hydrogen.

3.2 To demonstrate comprehension of the Quantum Mechanical Theory, students will:

(1) identify the de Broglie relationship;

(2) recognize the Schrodinger Wave Equation;

(3) identify and describe the four principal quantum numbers: n, l, m, and s;

(4) write a complete set of quantum numbers for each electron of the simpler elements;

(5) identify Pauli's Exclusion Principle;

(6) write the electron configuration for any atom or ion and draw the orbital diagram;

(7) apply Hund's Rule to orbital diagrams;

*(8) determine the number of unpaired electrons in an element when given the atomic number; and

(9) predict magnetic properties on the basis of the number of unpaired electrons.

3.3 To demonstrate knowledge of the Periodic Table, students will:

(1) review the structure of the Table and terms associated with the Table;

*(2) predict the location of an element in the Periodic Table when given the electron configuration;

(3) use the Periodic Table to predict relative values of the following properties of elements: atomic radius, electronegativity, ionization energy, and metallic character;

(4) explain observed changes in the values of the successive ionization energies for a given atom;

*(5) identify the element which has the larger atomic radius when given two elements in the same period in the Periodic Table;

*(6) predict the physical properties of an element when given those elements surrounding it in the Periodic Table; and

(7) use the Table to predict the common oxidation numbers of both monatomic elements and combined elements.

4.0 Chemical Bonding/Molecular Geometry

4.1 To demonstrate knowledge of ionic bonding, students will:

(1) describe and give examples of predominantly ionic compounds; and

(2) construct Lewis dot formulas for ionic compounds.

4.2 To demonstrate knowledge of covalent bonding, students will:

(1) describe and give examples of covalently bonded compounds;

*(2) determine whether a bond is predominantly non polar, polar, or ionic when given a table of electronegativity differences;

(3) compare bond length in compounds containing single, double, and triple bonds;

(4) compare bond energies in compounds containing single and multiple bonds; and

(5) identify electron density differences in sigma and pi bonds.

4.3 To demonstrate knowledge of molecular geometry, students will:

(1) draw Lewis structures for molecules and polyatomic ions;

*(2) predict hybridization around the central atom of a simple molecule when given the formula;

*(3) predict shape of a molecule or polyatomic ion using the Lewis structures when given the formula;

(4) predict dipole moment of molecules;

(5) draw Lewis structures for compounds exhibiting resonance;

(6) determine the formal charge on each atom in a compound exhibiting resonance;

(7) compare valence bond and molecular orbital theories for covalent bonding;

(8) write a molecular orbital diagram for a simple diatomic species and determine the bond order;

*(9) given the formula for a complex ion, determine its charge; and

(10) recognize bonding theories for coordination compounds.

5.0 Gases/Liquids/Solids

5.1 Students will describe the relationships and the variables in Boyle's Law and Charles' Law.

5.2 Students will discuss the kinetic theory of gases and the Boltzmann distribution curve for gas molecules.

5.3 To demonstrate comprehension of the Ideal Gas Law, students will:

(1) predict the effect of a change in given conditions;

*(2) solve for n, p, V or T when given the appropriate values for the other three variables and the constant R;

(3) calculate the density of a gas;

(4) calculate the molecular mass of a gas; and

(5) interpret deviations in terms of molecular behavior.

5.4 Students will relate the volumes of gases in a reaction involving gases, using the Gay-Lussac Law of combining volumes.

*5.5 Students will calculate the partial pressure of a gas in a mixture of gases when given the total pressure and the number of moles of each component, using Dalton's Law.

5.6 To demonstrate knowledge of Graham's Law, students will:

(1) state the relationship between rate of effusion and average speed of gas molecules; and

(2) calculate the molecular mass of an unknown gas from comparison of effusion data with that of a known gas.

5.7 To demonstrate knowledge of the behavior of liquids, students will:

(1) describe liquid-vapor equilibrium and the conditions that affect an equilibrium system;

(2) explain the relationship that exists between the boiling point of a liquid and the vapor pressure of the liquid;

(3) describe the attractive forces that can exist between molecules of liquids;

(4) use the Clausius-Clapeyron equation to determine heat of vaporization; and

+(5) determine the molecular mass of a volatile liquid.

5.8 To demonstrate knowledge of solids, students will:

(1) classify ionic, molecular, macromolecular, and metallic solids on the basis of types of attractive forces present between units of the solid;

(2) describe the way in which physical properties of a solid are dependent upon the attractive forces between units in the solid;

*(3) predict the intermolecular forces that exist in a solid when given the name of the solid; and

(4) calculate densities from structural data.

5.9 To demonstrate knowledge of phase changes, students will:

(1) define terms relating to phase changes;

(2) draw and label diagrams illustrating phase changes for various substances; and

*(3) calculate enthalpy change when a specified number of grams of a substance is heated or cooled over a temperature range involving a phase change, given the necessary physical constants.

6.0 Solutions

6.1 To demonstrate knowledge of solution concentrations, students will:

(1) define and calculate molarity, molality, and weight percentage;

*(2) determine the number of moles of a substance present in a specified volume of a solution of known molarity;

(3) define mole fraction; and

*(4) calculate the mole fraction of a solution component when given the number of grams of each component in the solution.

6.2 To demonstrate knowledge of solubility, students will:

(1) describe the solution process;

(2) discuss the energy changes that occur during the solution process;

*(3) compare the solubility of a polar substance in nonpolar and polar solvents;

(4) relate the solubility of a gas in a liquid to its partial pressure, using Henry's Law; and

(5) discuss the effects of temperature and pressure on the solubility of solids and gases in liquids.

6.3 Students will relate the effect of solute concentration on solvent vapor pressure, using Raoult's Law.

6.4 To demonstrate knowledge of colligative properties, students will:

(1) discuss the relationship of vapor pressure lowering to the colligative properties of solutions;

*(2) calculate the molecular weight of a non-electrolyte when given the amount of freezing point lowering of a solution containing a specified amount of solute in a specified amount of solvent and the molal freezing point constant for the solvent;

●(3) determine the molecular weight by freezing point depression; and

(4) compare the effects on colligative properties for electrolytes and non-electrolytes.

6.5 Students will describe how a colloid differs from a true solution.

7.0 Gaseous Equilibria/K_{sp}

7.1 To demonstrate knowledge of gaseous equilibria, students will:

(1) write the equilibrium constant expression for a chemical reaction involving either homogeneous or heterogeneous substances;

*(2) calculate the numerical value for the equilibrium constant when given the balanced chemical equation and the equilibrium concentrations or pressures;

(3) calculate the equilibrium constant for a chemical reaction involving gases when given the original concentrations of all species and the equilibrium concentration of one species;

*(4) predict the extent of the reaction at equilibrium when given the K_c value;

(5) interconvert K_c and K_p;

(6) predict the direction a given chemical system will move to reach equilibrium when given the K_c value;

(7) use Le Chatelier's Principle to predict the effects of temperature and volume changes on an equilibrium system;

(8) use Le Chatelier's Principle to predict the direction a given equilibrium system will move to reestablish equilibrium if the concentration of one of the reactants is increased or decreased;

+(9) determine an equilibrium constant; and

(10) discuss how the change in the equilibrium constant with a change in temperature is related to enthalpy for the reaction.

7.2 To demonstrate knowledge of the solubility product constant, students will:

(1) write net ionic equations and K_{sp} expressions for slightly soluble salts;

*(2) identify the K_{sp} expression, when given the correct formula for a slightly soluble salt;

*(3) calculate the solubility in moles per liter when given the correct formula for a slightly soluble salt and the K_{sp} value;

(4) calculate the K_{sp} value from solubility data;

(5) predict the effect of common ion additions on solubility;

(6) use the K_{sp} value to determine whether precipitation will occur when two solutions are mixed; and

(7) decide which of two possible precipitates will form when two solutions are mixed, using the K_{sp} values.

8.0 Acids/Bases/Salts

8.1 To demonstrate knowledge of acids and bases, students will:

(1) define acids and bases using the Arrhenius, Bronsted-Lowry, and Lewis theories;

(2) state general properties of acids and bases;

(3) write ionic equations to illustrate the ionization of acids and dissociation of bases in water;

(4) identify acids and bases that are strong and weak;

(5) state that the strength is dependent upon the degree of ionization of the solute in the solvent;

(6) explain how acid strength relates to the nature of the covalent bond bwtween the acidic hydrogen and the element to which it is bonded;

*(7) identify the strongest acid when given four binary acids;

(8) compare the relative strengths of oxyacids;

*(9) identify the conjugate acid-base pairs when given the balanced equation for an acid-base reaction; and

(10) predict whether the reactants or products are favored in an acid-base reaction using a chart of relative strengths of acids and bases.

8.2 To demonstrate knowledge of salts, students will:

(1) discuss how the properties of a neutral solution differ from those of acidic and basic solutions; and

*(2) predict whether a given ionic substance will be acidic, basic, or neutral in water solution.

9.0 Ionic Equilibria

9.1 To demonstrate knowledge of acid-base equilibrium reactions, students will:

(1) state that the product of the hydrogen and hydroxide ion concentrations has a constant value, K_w, in any water solution at 25°C;

(2) write the ionization constant expression for a weak acid;

(3) derive a pK expression from the K_a expression;

(4) calculate the hydrogen ion concentration for the water solution of a weak acid, given the K_a value and the molarity for a specified acid;

*(5) calculate the pH of a weak acid solution, given the K_a value and the molarity for a specified acid;

(6) calculate the percent ionization of a weak acid from the pH of a solution containing a known amount of the acid and the K_a of the acid;

(7) draw appropriate graphs to illustrate titration of the various combinations of strong and weak acids and bases;

(8) write net ionic equations for acid-base reactions using various combinations of strong and weak acids and bases;

*(9) calculate the concentration of acid or base in a solution at any point in a titration process, using titration data;

+(10) determine the gram equivalent weight of an acid from titration data;

(11) select an appropriate indicator for an acid-base titration on the basis of the K_a value of the indicator;

*(12) calculate the hydrogen ion concentration of a buffered solution, given the composition of the buffer;

(13) calculate the pH of a buffer before and after the addition of known amounts of a strong acid or base, given the composition of the buffer; and

(14) relate the value of K_a for a weak acid to K_b for its conjugate base.

9.2 To demonstrate knowledge of complex ion equilibrium reactions, students will:

(1) write net ionic equations illustrating dissociation of complex ions;

(2) write dissociation constant expressions; and

(3) calculate concentrations of the species present, given the dissociation constant.

9.3 To demonstrate knowledge of multiple equilibria situations, students will:

(1) calculate an equilibrium constant for the process of dissolving an insoluble compound in a complexing agent using multiple equilibria;

(2) define amphoterism and give examples of amphoteric substances; and

●(3) perform qualitative analysis and separation by collecting data in the laboratory.

10.1 Oxidation-Reduction/Electrochemistry

10.1 To demonstrate knowledge of oxidation and reduction, students will:

(1) define oxidation, reduction, oxidizing agent, reducing agent, oxidation number, and half reaction;

(2) determine the oxidation number for all the elements in the reactants and products of a redox reaction;

(3) write the oxidation-reduction half reactions for a redox equation;

(4) identify the coefficients necessary to balance an oxidation-reduction equation by using the ion-electron method; and

(5) use the Activity Series of Elements Table to predict whether one element will or will not replace a second element.

10.2 To demonstrate knowledge of electrochemistry, students will:

(1) define Faraday, coulomb, anode, cathode, electrolysis, electrolytic cell, and voltaic cell;

(2) use Faraday's Law to relate the amount of electricity passed through a chemical cell to the amounts of substances produced or consumed at the electrodes;

(3) write the description of a cell using standard cell notation;

(4) sketch the electrolytic cell corresponding to a given redox reaction, label the anode and cathode, and trace the flow of current through the cell;

(5) sketch the voltaic cell corresponding to a given redox reaction, label the anode and cathode, and trace the flow of current through the cell;

+(6) determine the equivalent weight of an element from data obtained by use of a chemical cell;

(7) use standard electrode potentials to compare relative strengths of different reducing/oxidizing agents;

(8) calculate a cell voltage at standard conditions given the balanced redox equation for the cell and the E^0 table;

(9) determine whether a given cell will occur spontaneously at standard conditions using E^0 values for the half reactions;

(10) calculate ΔG^0 for a cell at equilibrium using the equation $\Delta G^0 = nFE^0$; and

(11) make concentration and E^0 calculations using the Nernst equation.

11.0 Kinetics/Thermodynamics

11.1 To demonstrate knowledge of kinetics, students will:

(1) define and calculate average rate for given reactions;

(2) graph concentration of a reactant as a function of time and determine the rate of reaction using the slope of the tangent;

(3) write the rate expression for a given reaction;

(4) determine the order of a reaction from experimental data;

(5) give appropriate units for the rate constant, k, for zero, first and second order reactions;

(6) calculate the rate constant, k, using the rate expression for a specified reaction;

(7) list the factors affecting the rate of a reaction;

+(8) determine rate of reaction;

(9) define activation energy;

(10) interpret activation energy diagrams;

(11) discuss the effect catalysts have on activation energy and on the rate of reaction;

(12) determine the activation energy for a reaction using data relating temperature to the rate constant and the Arrhenius equation/ and

(13) discuss reaction mechanisms.

11.2 To demonstrate knowledge of thermodynamics, students will:

(1) define enthalpy change for exothermic and endothermic reactions;

(2) write thermochemical equations for chemical processes and reactions;

(3) calculate the enthalpy change for a chemical process, using enthalpy values for the appropriate related processes and Hess's Law;

(4) calculate the enthalpy change for a reaction using heats of formation or using bond energies;

+(5) determine the enthalpy change for a reaction.

(6) obtain the specific heat of a substance using calorimetric data;

(7) define heat capacity;

(8) state the First Law of Thermodynamics;

(9) define state functions, system, and surroundings;

(10) calculate the change in internal energy for a system;

(11) define entropy and free energy;

(12) calculate entropy change for a chemical process;

(13) calculate standard free energy using the Gibbs-Helmholtz equation;

(14) predict reaction spontaneity using free energy, enthalpy, and entropy changes;

(15) relate free energy change to the equilibrium constant and perform appropriate calculations; and

(16) relate free energy change to electrode potentials.

12.0 Nuclear/Organic

12.1 To demonstrate knowledge of nuclear reactions, students will:

(1) identify the basic types of radiation as alpha, beta, and gamma;

(2) write a balanced equation for a nuclear reaction, given the identities of all but one reactant and product;

(3) calculate the half-life of a radioactive species using the first order rate law;

(4) discuss the effect of radiation on materials and human beings; and

(5) calculate the energy change accompanying a nuclear reaction when given the appropriate nuclear masses.

12.2 To demonstrate knowledge of organic chemistry, students will:

(1) draw the structural formula, given the molecular formula;

(2) relate physical properties of hydrocarbons to molecular weights and structure;

(3) use the IUPAC naming system for the simpler unsaturated and saturated hydrocarbon compounds;

(4) identify some of the isomer types such as structural and geometric;

(5) classify organic compounds with functional groups and draw structural formulas of acids, alcohols, ketones, aldehydes, and ethers; and

(6) identify the common reactions of hydrocarbons as: combustion, halogenation or addition, oxidation, and esterification.

KEY TO RECOMMENDED INSTRUCTIONAL MATERIALS

Performance Objective		Instructional Implications		Resources	
Number	Topic	Teaching Time	Tested on	County Adopted	Supplementary
1.0	Measurement/ Atomic Theory/ Atomic Structure	1-2 weeks	MLST	W. L. Masterton, et al, Chemical Principles (Philadelphia: Saunders College Publishing, 1981). pp. 1-45.	
2.0	Chemical Formulas/ Chemical Equations/ Stoichiometry	2-3 weeks	MLST	Masterton, pp. 49-76.	
3.0	Electron: Energies/ Arrangement/ Periodic Table	2-3 weeks	MLST	Masterton, pp. 162-90.	C. E. Mortimer, Chemistry, A Conceptual Approach (New York, N.Y.: Van Nostrand Reinhold Company, 1971), pp. 38-80.
4.0	Chemical Bonding/ Molecular Geometry	3-4 weeks	MLST	Masterton, pp. 220-43, 452-69.	Mortimer, pp. 81-93, 106-36, 665-89.

KEY TO RECOMMENDED INSTRUCTIONAL MATERIALS

Performance Objective		Instructional Implications		Resources	
Number	Topic	Teaching Time	Tested on	County Adopted	Supplementary
5.0	Gases/ Liquids/ Solids	3-4 weeks	MLST	Masterton, pp. 135-58, 246-69.	Mortimer, pp. 168-95.
6.0	Solutions	2-3 weeks	MLST	Masterton, pp. 68-72, 150, 376-96.	Mortimer, pp. 282-86.
7.0	Gaseous Equilibria/ Ksp	4-5 weeks	MLST	Masterton, pp. 303-19, 428-33.	Mortimer, pp. 498-501.
8.0	Acids/Bases/ Salts	1 week	MLST	Masterton, pp. 400-24.	Mortimer, pp. 519-38.
9.0	Ionic Equilibria	4-5 weeks	MLST	Masterton, pp. 412-18, 428-47.	Mortimer, pp. 542-610.
10.0	Oxidation-Reduction/ Electro-chemistry	1-2 weeks		Masterton, pp. 492-542.	Mortimer, pp. 309-42.

KEY TO RECOMMENDED INSTRUCTIONAL MATERIALS

Performance Objective		Instructional Implications		Resources	
Number	Topic	Teaching Time	Tested on	County Adopted	Supplementary
11.0	Kinetics/ Thermodynamics	1-2 weeks		Masterton, pp. 324-46, 106-22, 546-63.	Mortimer, pp. 471-512, 445-65.
12.0	Nuclear/ Organic	1 week		Masterton, pp. 567-88, 592-638.	Mortimer, pp. 736-61, 692-731.

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KEY TO LABORATORY RESOURCES

Objective	Skill	County Adopted Text Pages	Other Resources
	Students will:		
2.1.6	determine the empirical formula of a hydrate from data collected in the laboratory.		H. C. Metcalfe, et al, Exercises and Experiments in Modern Chemistry (New York: Holt, Rinehart, and Winston, 1982), pp. 151-54.
2.2.5	determine mass and mole relationships from data collected in the laboratory.		Metcalfe, pp. 155-58. L. E. Malm, Laboratory Manual for Chemistry An Experimental Science (San Francisco: W. H. Freeman and Company, 1963), p. 19.
3.1.6	analyze the atomic spectrum of hydrogen.	75-81	
5.7.5	determine the molecular mass of a volatile liquid.	69-73	M. J. Sienko and R. A. Plane, Experimental Chemistry (New York: McGraw-Hill, Inc., 1972), p. 78.
6.4.3	determine the molecular weight by freezing point depression.	173-82	
7.1.9	determine an equilibrium constant.	199-203	

(Philadelphia: Saunders College Publishing, 1981).

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INTRODUCTION
PHYSICAL SCIENCE II

State Accreditator Number. .	1355
Course Code Number	2530
F.T.E. Category.	1.10
Instructional Level.	Standard

Report Card Abbreviation . .	Phys Sci II
Length of Course	Year
Credit	1 Science credit
Grade Level.	10, 11, 12

Prerequisites

None

Textbook(s)

Blecha, M. K., et al, Exploring Matter and Energy (River Forest, Illinois: Laidlaw Brothers, 1980).

Tracy, G. R., et al, Modern Physical Science (New York: Holt, Rinehart, and Winston, 1979).

Notes to Teachers

Changes have been made in the content and format of the Course Outline, and in the Performance Objectives for Physical Science II. Full objectives are included in addition to the Minimum Level Skills objectives (MLS). Students are to develop laboratory skills as well as content knowledge.

The MLS are indicated with an asterisk (*), and will be the only objectives tested on the Minimum Level Skills Test (MLST). All MLS objectives must be taught before the MLST.

Laboratory skills are indicated with a plus sign (+). Suggested resources for teaching the laboratory skills have been listed at the end of this section of the teacher's guide in order of preference. Teachers may substitute other resources for the indicated laboratory investigations. Additional laboratory investigations are encouraged. Since further curriculum development may occur for this course, it is suggested that teachers keep a record of additional laboratory investigations and their source.

PHYSICAL SCIENCE II

1.0 Scientific Skills

- *1.1 Metric Prefixes
- *1.2 Metric Units of Measure
- *1.3 Metric Conversions
- +1.4 Measurements
- 1.5 Scientific Method
  - 1.5.1 Procedure
  - 1.5.2 Independent/ Dependent variables
  - 1.5.3 Conclusions
  - +1.5.4 Data collection/ Analysis
- 1.6 Graphing Techniques
  - 1.6.1 Scales/Labels
  - +1.6.2 Construction
- 1.7 Graph Analysis
  - 1.7.1 Range graphs
  - *1.7.2 Direct/Indirect relationships

2.0 Matter

- 2.1 Mass/Weight
  - 2.1.1 Definitions
  - *2.1.2 Mass vs. weight
- 2.2 Chemical/Physical Changes
  - 2.2.1 Differences
  - +2.2.2 Chemical/Physical change observations
- 2.3 Atomic Structure
  - *2.3.1 Nucleus
  - 2.3.2 Energy Levels
  - 2.3.3 Electron configuration
- *2.4 Elements
  - 2.4.1 Definitions
  - 2.4.2 Symbols/Names
- 2.5 Periodic Table
  - *2.5.1 Atomic number
  - *2.5.2 Atomic weight
  - *2.5.3 Locations: metals, nonmetals, rare gases
  - 2.5.4 Periods/Groups
  - 2.5.5 Applications
- 2.6 Compounds
  - *2.6.1 Definitions
  - *2.6.2 Formulas vs. symbols
  - *2.6.3 Bonds: ionic, covalent
  - 2.6.4 Simple formulas
- 2.7 Chemical Equations
  - 2.7.1 Form/Terminology
  - *2.7.2 Conservation: matter
  - 2.7.3 Equations
  - +2.7.4 Conservation confirmation
- 2.8 Acids/Bases
  - *2.8.1 Identification: acids, bases
  - 2.8.2 pH
  - 2.8.3 Properties
  - +2.8.4 Testing: acids, bases
- 2.9 Neutralization Reactions
  - *2.9.1 Products
  - 2.9.2 Equations
- 2.10 Chemical Solutions
  - 2.10.1 Characteristics: solutions
  - 2.10.2 Solubility factors
  - +2.10.3 Solubility factors investigation

3.0 Environment/Energy Crisis

- 3.1 Air Pollution
  - *3.1.1 Problems
  - 3.1.2 Solutions
  - +3.1.3 Air pollution investigations
- 3.2 Water Pollution
  - *3.2.1 Problems
  - 3.2.2 Solutions
  - +3.2.3 Water pollution investigations
- 3.3 Energy Crisis
  - *3.3.1 Fossil fuels
  - 3.3.2 Causes
  - 3.3.3 Economics
  - 3.3.4 Solutions

* Indicates Minimum Level Skills
\+ Indicates Laboratory Skills

PHYSICAL SCIENCE II

4.0 Nuclear Energy

- *4.1 Definitions
- 4.2 Radioactivity
  - 4.2.1 Isotopes
  - 4.2.2 Types of radiation
  - 4.2.3 Half-life
  - 4.2.4 Transmutations
  - 4.2.5 Safety precautions
  - +4.2.6 Half-life investigations
- *4.3 Fission/Fusion
- 4.4 Environmental Concerns

5.0 Dynamics/Mechanics

- 5.1 Forces
  - *5.1.1 Definition
  - 5.1.2 Types
- 5.2 Newton's Laws: Motion
  - *5.2.1 First Law
  - *5.2.2 Second Law
  - 5.2.3 Third Law
  - +5.2.4 F = ma confirmation
- 5.3 Gravity
  - 5.3.1 As g = 9.8 m/sec^2
  - 5.3.2 Vacuum: fall rate
  - +5.3.3 Gravitational constant confirmation
- 5.4 Pressure
  - *5.4.1 Definition: F/A
  - 5.4.2 Calculations
  - 5.4.3 Pascal's Law
  - 5.4.4 Boyle's Law
  - +5.4.5 Boyle's Law investigation
  - 5.4.6 Bernoulli's Principle
- 5.5 Energy
  - *5.5.1 Definition
  - *5.5.2 Forms/ Transformations
  - *5.5.3 Kinetic/Potential energy
  - +5.5.4 Kinetic/Potential: relationships

6.0 Simple Machines

- 6.1 Definition/Usage: Machines
- 6.2 Levers
  - *6.2.1 First class/ Second class levers
  - 6.2.2 Third class levers
  - *6.2.3 Ideal mechanical advantage
  - *6.2.4 Computations
  - +6.2.5 Investigations
- 6.3 Pulleys
  - *6.3.1 Simple pulley
  - *6.3.2 Block and Tackle
  - 6.3.3 IMA
  - 6.3.4 Calculations
  - +6.3.5 Investigations
- 6.4 Inclined Planes
  - *6.4.1 Examples/ Variations
  - 6.4.2 IMA
  - +6.4.3 Observations
- 6.5 Work
  - *6.5.1 Definition
  - *6.5.2 Work in/Work out
  - 6.5.3 Efficiency
  - +6.5.4 Investigations
- 6.6 Power
  - *6.6.1 Definition
  - 6.6.2 Calculations

PHYSICAL SCIENCE II

7.0 Electricity/Magnetism

- 7.1 Electrostatics
  - *7.1.1 Law: electrostatics
  - +7.1.2 Electrostatic charges
  - *7.1.3 Insulators/ Conductors
  - +7.1.4 Conduction tests
- *7.2 Current Electricity Definitions
  - 7.2.1 Volt
  - 7.2.2 Ampere
  - 7.2.3 Ohm
  - 7.2.4 Watt
- *7.3 Circuits: Series/ Parallel
- *7.4 Ohm's Law
- +7.5 Circuit Tests
- 7.6 Circuit Calculations
- 7.7 Magnets
  - *7.7.1 Interaction: poles
  - +7.7.2 Magnetic field mapping
  - 7.7.3 Domains
  - 7.7.4 Electromagnets
  - +7.7.5 Strength factors

8.0 Heat

- 8.1 Temperature/Heat
- 8.2 Temperature Scales
- 8.3 Phase Changes
  - 8.3.1 Fusion point
  - 8.3.2 Vaporization point
  - 8.3.3 Phase graph
  - 8.3.4 Specific heat calculations
- +8.4 Latent Heat Experiments
- +8.5 Thermal Expansion
- 8.6 Heat Transfer

9.0 Wave Motion

- 9.1 Wave Properties
- 9.2 Wave Types
- +9.3 Observations
- 9.4 Wave Front Interactions
- 9.5 Sound
  - 9.5.1 Description
  - 9.5.2 Sound speed
  - 9.5.3 Frequency/Pitch
  - 9.5.4 Amplitude/Loudness
  - 9.5.5 Doppler effect
  - 9.5.6 Decibels
  - 9.5.7 Resonance
  - +9.5.8 Experiments

PERFORMANCE OBJECTIVES
PHYSICAL SCIENCE II

To demonstrate the ability to recall and apply knowledge of scientific skills, matter, the environment and the energy crisis (problems and solutions), nuclear energy, dynamics and mechanics, simple machines, electricity, magnetism, heat, and wave motion, students will master the performance objectives listed below. Successful completion of this course is based on teacher judgement and the requirement that students pass the Minimum Level Skills Test.

Performance Objectives

1.0 Scientific Skills

*1.1 Students will match the metric prefixes milli-, centi-, deci-, and kilo- with their respective numerical values.

*1.2 Students will identify the metric units of measure for length, mass, volume, time, and density.

*1.3 Students will convert a metric measure to an equivalent metric measure.

+1.4 Students will measure length, mass, volume, and density when given the appropriate laboratory equipment: meterstick, balance, and graduated cylinder.

1.5 To demonstrate knowledge of the scientific method, students will:

(1) identify the steps of the procedure used in the scientific method;

(2) identify the independent and dependent variables when given specific problems;

(3) draw appropriate conclusions when given data; and

+(4) collect and analyze data, and draw appropriate conclusions for an investigative problem.

1.6 To demonstrate knowledge of graphing techniques, students will:

(1) select the correct scaling and labeling of a line graph when given the appropriate data; and

+(2) construct a graph from data obtained from an experiment.

1.7 To demonstrate knowledge of graph analysis, students will:

(1) draw a daily temperature graph when given or having collected the appropriate data; and

*(2) identify graphs that represent direct or indirect relationships between two variables.

2.0 Matter

2.1 To demonstrate knowledge of mass and weight, students will:

(1) identify the definitions for mass and weight; and

*(2) differentiate between mass and weight, where mass remains unchanged with location, and weight decreases with increased distance from earth.

2.2 To demonstrate knowledge of chemical and physical changes, students will:

(1) explain the differences between chemical and physical changes; and

+(2) observe chemical and physical changes in laboratory investigations.

2.3 To demonstrate knowledge of atomic structure, students will:

*(1) identify the atomic particles that are found in the nucleus of the atom;

(2) identify the maximum number of electrons which can be found in a specified energy level; and

(3) identify the electron configuration of a specified element, atomic number 1-20.

*2.4 To demonstrate knowledge of elements, students will:

(1) identify the definition of an element; and

(2) identify the symbols and names of selected common elements: H, He, C, N, O, Ne, Na, S, Cl, K, Fe, Cu, or U.

2.5 To demonstrate knowledge of the Periodic Table, students will:

*(1) identify the atomic number of an element when given the information that appears on the Periodic Table about that element;

*(2) determine the atomic weight of an element when given the number of protons, neutrons, and electrons;

*(3) identify the locations of the metals, nonmetals, and rare gases on the Periodic Table;

(4) identify the relationship between elements in the same group as having the same number of electrons in the outer shell, and identify the period as the horizontal arrangement of elements in increasing atomic number; and

(5) draw simple orbital diagrams of atoms.

2.6 To demonstrate knowledge of compounds, students will:

*(1) identify the definition of a compound;

*(2) distinguish between examples of chemical formulas and chemical symbols;

*(3) distinguish between definitions of ionic and covalent bonds; and

(4) write simple chemical formulas.

2.7 To demonstrate knowledge of chemical reactions, students will:

(1) explain the form and terminology of a chemical equation;

*(2) identify a balanced chemical equation as representative of conservation of matter;

(3) balance chemical equations; and

+(4) confirm the principle of conservation of matter through laboratory investigations.

2.8 To demonstrate knowledge of acids and bases, students will:

*(1) identify the ions that are characteristic of acids, H^+, and of bases, OH^-;

(2) define pH as the expression of the acidity or alkalinity of a solution;

(3) identify various properties of acids and bases; and

+(4) identify examples of acids and bases using laboratory procedures.

2.9 To demonstrate knowledge of neutralization reactions, students will:

*(1) identify the products of a neutralization reaction as a salt and water; and

(2) write and balance equations representing neutralization reactions.

2.10 To demonstrate knowledge of chemical solutions, students will:

(1) identify characteristics of specified solutions, using the terms solute, solvent, and saturated;

(2) identify the solubility factors of a solid as heat, surface area, and stirring; and

+(3) investigate the solubility factors.

3.0 Environment/Energy Crisis

3.1 To demonstrate knowledge of air pollution, students will:

*(1) identify automobiles as the major cause of air pollution;

(2) discuss possible solutions to the problem of air pollution and the implications thereof; and

+(3) examine air pollution problems using laboratory experiments.

3.2 To demonstrate knowledge of water pollution, students will:

*(1) identify the water pollution problems produced by industry, domestic use, and of pesticides and fertilizers in agriculture;

(2) discuss possible solutions to these problems and their effect on the populations involved; and

+(3) examine the effects of water pollution.

3.3 To demonstrate knowledge of energy conservation, students will:

*(1) identify the fossil fuels as oil, gas, and coal;

(2) summarize the various causes of the energy crisis;

(3) evaluate the economic situation that is produced by the energy crisis; and

(4) discuss feasible solutions to the energy crisis.

4.0 Nuclear Energy

*4.1 Students will define nuclear energy as energy obtained from the nuclei of atoms.

4.2 To demonstrate knowledge of radioactivity, students will:

(1) define isotope;

(2) identify the three types of radiation produced during radioactive decay;

(3) define half-life;

(4) indicate the nuclear changes that take place during radioactive decay, and transmutation;

(5) list several safety precautions necessary when working near radioisotopes; and

+(6) demonstrate the meaning of half-life using laboratory investigations.

*4.3 Students will differentiate between definitions of fission and fusion reactions.

4.4 Students will evaluate the environmental concern for and against the nuclear power industry.

5.0 Dynamics/Mechanics

5.1 To demonstrate knowledge of forces, students will:

*(1) define force as a push or a pull; and

(2) identify some forces as friction, gravitation, adhesion and cohesion, buoyancy, and electric.

5.2 To demonstrate knowledge of Newton's Laws of Motion, students will:

*(1) name inertia as an example of Newton's First Law;

*(2) identify the mathematical formula, $F = ma$, as Newton's Second Law;

(3) identify walking as an example of Newton's Third Law; and

+(4) confirm $F = ma$ in experimental situations.

5.3 To demonstrate knowledge of gravitation, students will:

(1) identify $g = 9.8\ m/sec^2$ as the approximate value for the acceleration of gravity near the surface of the earth;

(2) recognize that the rate of acceleration in a vacuum is the same for all masses at or near the same surface; and

+(3) demonstrate that for all masses acceleration for free fall is constant.

5.4 To demonstrate knowledge of pressure, students will:

*(1) define pressure as force divided by area, $P = F/A$;

(2) compute the pressure when given the appropriate data;

(3) identify Pascal's Law as the law that states that pressure on a confined liquid is transmitted equally in all directions;

(4) identify $P_1V_1 = P_1V_1$ as Boyle's Law;

+(5) investigate Boyle's Law; and

(6) identify an example of Bernoulli's Principle.

5.5 To demonstrate knowledge of energy, students will:

*(1) define energy as the ability to do work;

*(2) identify examples of mechanical, heat, light, sound, chemical, and electrical transformations;

*(3) differentiate between the definitions of potential and kinetic energy; and

+(4) observe examples of potential and kinetic energy in a system and describe how this energy is transformed from one to another.

6.0 Simple Machines

6.1 Students will define a machine as something that makes work easier by changing either the direction of the force or by multiplying the force applied.

6.2 To demonstrate knowledge of levers, students will:

*(1) identify a drawing of a first and second class lever;

(2) describe how a third class lever makes work easier;

*(3) define the ideal mechanical advantage (IMA) of a lever as the effort arm divided by the resistance arm;

*(4) compute the IMA from a drawing with given values; and

+(5) determine experimentally the IMA of various levers.

6.3 To demonstrate knowledge of pulleys, students will:

*(1) identify a simple pulley as one that changes the direction of an applied force, but not the amount of force;

*(2) determine the IMA of a block and tackle by counting the resistance support strands when given a diagram;

(3) define the IMA of a block and tackle as the effort distance divided by the resistance distance;

(4) calculate the IMA when given the appropriate measures; and

+(5) test various arrangements of pulleys and block and tackle.

6.4 To demonstrate knowledge of inclined planes, students will:

*(1) identify variations of the inclined plane as a wedge, and screws;

(2) define the IMA of an inclined plane as the length divided by the height; and

+(3) observe and test various inclined planes.

6.5 To demonstrate knowledge of work by machines, students will:

*(1) define work as the force acting through a distance;

*(2) identify the principle that in a frictionless system work put into a machine equals work out, $W_i = W_o$;

(3) calculate the efficiency of a machine in a system with friction; and

+(4) construct simple machines and investigate the work and efficiency of each.

6.6 To demonstrate knowledge of the power produced by machines, students will:

*(1) define power as the rate of doing work; and

(2) calculate the power produced by a machine when given force, distance, and time interval.

7.0 Electricity/Magnetism

7.1 To demonstrate knowledge of electrostatics, students will:

*(1) recall that like electrostatic charges repel and unlike charges attract;

+(2) make observations of electrostatically charged objects;

*(3) differentiate between examples of electric conductors and insulators; and

+(4) test electrical conduction.

*7.2 To demonstrate knowledge of electrical units of measurement students will define:

(1) volt as a unit of potential difference;

(2) ampere as the unit of current represented by the number of electrons per second;

(3) ohm as the unit of resistance; and

(4) watt as the unit of power.

*7.3 Students will identify series and parallel circuits when given diagrams of simple circuits.

*7.4 Students will identify Ohm's Law as V = IR.

+7.5 Students will wire series and parallel circuits and determine the resistance of each circuit.

7.6 Students will calculate the voltage of a simple circuit given the amperage, resistance, and type of circuit.

7.7 To demonstrate knowledge of magnets, students will:

*(1) recall that like magnetic poles repel and unlike magnetic poles attract;

+(2) map magnetic fields;

(3) explain that magnetism is a result of domains;

(4) identify an electromagnet as a current carrying wire wound around an iron core; and

+(5) test the factors which increase the strength of an electromagnet: wire gauge, number of turns, or core metal.

8.0 Heat

8.1 Students will distinguish between heat and temperature.

8.2 Students will convert temperature measurements from one temperature scale to other temperature scales using the Fahrenheit, Celsius, or Kelvin scales.

8.3 To demonstrate knowledge of phase changes, students will:

(1) define fusion point;

(2) define vaporization point;

(3) locate the fusion and vaporization points on a phase graph; and

(4) calculate the heat liberated or absorbed when given the specific heat, mass, and the temperature change.

+8.4 Students will conduct latent heat experiments.

+8.5 Students will observe thermal expansion of solids, liquids, and gases.

8.6 Students will compare the transfer of heat by conduction, convection, and radiation.

9.0 Wave Motion

9.1 Students will identify the properties of wave motion.

9.2 Students will distinguish between two types of waves motion.

+9.3 Students will observe examples of the two types of wave motion.

9.4 Students will describe reinforcement and interference as they apply to wave front interaction.

9.5 To demonstrate knowledge of sound, students will:

(1) describe how sound is produced;

(2) identify the speed of sound at 0°C;

(3) compare frequency and pitch;

(4) compare amplitude and loudness;

(5) describe an explanation for the Doppler effect;

(6) define decibel;

(7) describe the effect of resonance on the pitch of a sound; and

+(8) conduct experiments on the properties of sound.

KEY TO RECOMMENDED INSTRUCTIONAL MATERIALS

Performance Objective		Instructional Implications		Resources	
Number	Topic	Teaching Time	Tested on	County Adopted	Supplementary
1.0	Scientific Skills	3 weeks	MLST	G. R. Tracy, et al, Modern Physical Science (New York: Holt, Rinehart, and Winston, 1979), Chapter 1.	M. K. Blecha, et al, Exploring Matter and Energy (River Forest, Illinois: Laidlaw Brothers, 1980), Chapters 1-4.
2.0	Matter	6 weeks	MLST	Tracy, Chapters 2-5, 7, 8, 10.	Blecha, Chapters 5, 6, 8, 9, 18.
3.0	Environment/ Energy Crisis	4 weeks	MLST	Tracy, Chapters 9, 12.	Blecha, Chapter 27.
4.0	Nuclear Energy	2 weeks	MLST	Tracy, Chapter 6.	Blecha, pp. 159-67, 180-84.
5.0	Dynamics/ Mechanics	6 weeks	MLST	Tracy, Chapters 16, 18, 19.	Blecha, Chapters 10-12.
6.0	Simple Machines	3 weeks	MLST	Tracy, Chapters 17, 19.	Blecha, Chapter 13.
7.0	Electricity/ Magnetism	3 weeks	MLST	Tracy, Chapters 25-28.	Blecha, Chapters 15-19.

Performance Objective		Instructional Implications		Resources	
Number	Topic	Teaching Time	Tested on	County Adopted	Supplementary
8.0	Heat	2 weeks		Tracy, Chapters 4, 20.	Blecha, Chapter 7.
9.0	Wave Motion	2 weeks		Tracy, Chapters 22, 23.	Blecha, pp. 20-22.

Science (New York: Holt, Rinehart, and Winston, 1979).

KEY TO LABORATORY RESOURCES

Objective	Skill	County Adopted Text Pages	Other Resources
	Students will:		
+1.4	measure length, mass, volume, and density when given the appropriate laboratory equipment (meterstick, balance, graduated cylinder).	8, 17	C. R. Barman, et al, Physical Science (Morristown, New Jersey: Silver Burdett Co., 1979), pp. 378-95. C. L. Bickel, et al, Physical Science Investigations, Revised Edition (Boston, Mass.: Houghton Mifflin Company, 1979), Chapter 2. M. K. Blecha, et al, Exploring Matter and Energy (River Forest, Illinois: Laidlaw Brothers, 1980), pp. 43, 50. S. M. Eisler, et al, Laboratory Inquiry Text: Physical Science (New York: Cambridge Book Company, 1972), pp. 35-64, 105-21. A. E. Friedl, et al, Exercises and Investigations for Modern Physical Science (New York: Holt, Rinehart, and Winston, 1979), Investigation 1-1. P. H. Joslin, Laboratory Investigations: Matter, Life and Energy (Chicago, Illinois: Rand McNally and Company, 1972), Investigations 1, 4, 43.

KEY TO LABORATORY RESOURCES

Objective	Skill	County Adopted Text Pages	Other Resources
	Students will:		V. Monson, Focus on Physical Science Activity Centered Program: Teacher's Guide (Columbus, Ohio: Charles E. Merrill Publishing Co., 1977), pp. 2, 4, 5, 6, 7, 47, 49. O. E. Perkins, et al, Physical Science Skillcards (Columbus, Ohio: Charles E. Merrill Publishing Co., 1969), Skillcard 44. G. A. Williams, et al, Challenges To Science: Physical Science (New York: McGraw-Hill Book Company, 1979), p. 62.
+1.5.4	draw appropriate conclusions for investigative problems after collecting and analyzing data.		Barman, p. 219. Belcha, pp. 18, 21, 24, 58, 63, 67. Eisler, pp. 3-32. Joslin, Investigation 2.
+1.6.2	construct a graph from data obtained from an experiment.		Barman, pp. 200-25. Eisler, pp. 67-96.

KEY TO LABORATORY RESOURCES

Objective	Skill	County Adopted Text Pages	Other Resources
	Students will:		
+2.2.2	observe physical and chemical changes in laboratory investigations.	21, 110, 120	Barman, pp. 50-2, 111, 133. Bickel, pp. 200-01. Blecha, p. 155. Eisler, pp. 99-103. Monson, pp. 44, 53. Perkins, Skillcards 38-40, 47-51.
+2.7.4	confirm the Law of Conservation of Mass.	27	Bickel, p. 202. Blecha, p. 224. Williams, p. 184.
+2.8.4	identify examples of acids and bases using laboratory procedures.	76, 81	Barman, pp. 166, 169, 170. Blecha, p. 158. Eisler, pp. 100-03. Friedl, Investigations 5-1, 5-2, 5-3.

KEY TO LABORATORY RESOURCES

Objective	Skill	County Adopted Text Pages	Other Resources
	Students will:		Monson, pp. 142-4, 147. Perkins, Skillcards 64-9. Williams, p. 239.
+2.10.3	investigate solubility factors (heat, surface area, stirring).		Barman, pp. 88, 93, 96. Monson, p. 114. Perkins, Skillcards 59-61.
+3.1.3	examine air pollution using laboratory techniques.	151	Belcha, p. 525. Environmental Science: Probing the Natural World, Level 3, (New York: Silver Burdett, 1972), Chapter 6. Friedl, Investigation 9-1.
+3.2.3	examine the effects of water pollution.	128, 129, 147	Barman, pp. 315, 319. Belcha, p. 530.

KEY TO LABORATORY RESOURCES

Objective	Skill	County Adopted Text Pages	Other Resources
	Students will:		Environmental Science, Chapter 4.
+4.2.6	demonstrate the statistical meaning of half-life using laboratory investigations.		Barman, p. 183. Williams, p. 441.
+5.2.4	confirm F = ma in experimental situations.		Blecha, p. 244. Eisler, pp. 129-59. Friedl, Investigation 16-3. Monson, pp. 26-40.
+5.3.3	demonstrate that for all masses acceleration in free fall is constant.	287	Blecha, p. 244.
+5.4.5	investigate Boyle's Law.	337	
+5.5.4	observe examples of kinetic and potential energy in a system and relate how this energy is transformed from one type to another.		Blecha, p. 208. Eisler, pp. 170-02.

KEY TO LABORATORY RESOURCES

Objective	Skill	County Adopted Text Pages	Other Resources
+6.2.5	determine, experimentally, the ideal mechanical advantage (IMA) of levers.	306-7	Barman, p. 209. Blecha, pp. 253, 258. Eisler, pp. 173-84, 189-92. Joslin, Investigation 16. Monson, p. 14. Perkins, Skillcards 2, 6. Williams, p. 84.
+6.3.5	test various arrangements of pulleys and of blocks and tackle.	306-7	Barman, p. 211. Monson, p. 14. Perkins, Skillcard 3.
+6.4.3	observe and test various inclined planes.	309-10	Barman, p. 206. Bickel, p. 59. Blecha, p. 263. Eisler, pp. 185-08.

KEY TO LABORATORY RESOURCES

Objective	Skill	County Adopted Text Pages	Other Resources
	Students will:		Friedl, Investigation 17-1. Monson, p. 16.
+6.5.4	construct simple machines and observe work done.	309	Barman, p. 213. Eisler, pp. 165-7. Joslin, Investigations 16, 17. Perkins, Skillcard 4.
+7.1.2	observe electrostatic charges interacting.	465	Barman, p. 117. Belcha, p. 293. Eisler, pp. 206-15. Friedl, Investigation 25-1. Joslin, Investigation 28. Monson, p. 209. Perkins, Skillcard 33. Williams, p. 301.

KEY TO LABORATORY RESOURCES

Objective	Skill	County Adopted Text Pages	Other Resources
	Students will:		
+7.1.4	test electrical conduction.		Eisler, pp. 216-18.
+7.5	wire series and parallel circuits and determine the series and parallel resistance of each circuit.	488	Barman, pp. 240, 250. Bickel, pp. 252, 255, 259, 262, 265, 268, 272, 275, 279, 280. Blecha, pp. 317, 320. Friedl, Investigation 26-1. Joslin, Investigation 30. Monson, p. 227. Williams, p. 341.
+7.7.2	map magnetic fields.	514	Blecha, p. 334. Eisler, pp. 195-205. Joslin, Investigation 32. Monson, p. 220. Perkins, Skillcard 34.

KEY TO LABORATORY RESOURCES

Objective	Skill	County Adopted Text Pages	Other Resources
+7.7.5	test factors which increase the strength of an electromagnet.	520	Barman, pp. 245, 247. Blecha, p. 340. Eisler, p. 221. Joslin, Investigation 33. Monson, p. 220. Perkins, Skillcard 37.
+8.4	perform latent heat experiments.	354, 367	Barman, p. 260. Joslin, Investigation 20. Monson, pp. 168-69. Perkins, Skillcards 13-16. Williams, p. 156.
+8.5	observe thermal expansion of a metal and liquid.	358-9	Barman, pp. 75, 268. Blecha, p. 140. Joslin, Investigation 21. Monson, p. 170.

KEY TO LABORATORY RESOURCES

Objective	Skill	County Adopted Text Pages	Other Resources
	Students will:		
+9.3	observe wave forms.	388-91	Belcha, p. 395. Monson, pp. 176-78. Williams, p. 397.
+9.5.8	conduct experiments on the properties of sound.	392, 396, 407	Blecha, pp. 412, 416, 420. Friedl, Investigations 22-1, 22-2.

INTRODUCTION
PHYSICS I

State Accreditator Number. . 1318
Course Code Number 2501
F.T.E. Category. 1.10
Instructional Level. . . . . Standard

Report Card Abbreviation . . Physics I
Length of Course . . . . . Year
Credit . . . . . 1 Science credit
Grade Level. 10, 11, 12

Prerequisites

Algebra I

Textbook(s)

Murphy, J. T. and Smoot, R. C., Physics Principles and Problems (Columbus, Ohio: Charles E. Merrill Publishing Co., 1977).

Notes to Teachers

Changes related to the recently-adopted county textbook have been made in the content of the course outline and in the performance objectives for Physics I, Standard. Full objectives are included in addition to the Minimum Level Skills objectives. Students are to develop laboratory skills as well as content knowledge.

The Minimum Level Skills (MLS) objectives are indicated with an asterisk (*), and will be the only objectives tested on the Minimum Level Skills Test (MLST). Three MLS objectives were changed or added due to the recently-adopted county textbook. The "Teaching Time" listed on the Key to Instructional Materials is a suggested maximum for each objective to help insure that all MLS objectives can be met by MLST time.

Laboratory skills are indicated with a plus sign (+). Suggested resources for teaching the laboratory skills have been listed at the end of this section of the teacher's guide. Teachers may substitute other resources for the indicated laboratory investigations. Additional laboratory investigations are encouraged. Since further curriculum development will occur for this course, it is suggested that teachers keep a record of additional laboratory investigations and their source.

PHYSICS I

1.0 Measurement and Graphing

- 1.1 Metric Units: MKS/cgs
  - 1.1.1 Length
  - 1.1.2 Area
  - 1.1.3 Volume
  - *1.1.4 Mass
  - 1.1.5 Time
  - +1.1.6 Length measurement
  - +1.1.7 Mass measurement
- *1.2 Metric Conversions
  - 1.2.1 Centimeter to meter
  - 1.2.2 Millimeters to centimeters
- *1.3 Metric Prefixes
  - 1.3.1 Kilo-
  - 1.3.2 Centi-
  - 1.3.3 Milli-
- *1.4 Scientific Notation
- 1.5 Graphs
  - *1.5.1 Direct variation: linear
  - 1.5.2 Inverse variation: hyperbolic
  - +1.5.3 Construction
- 1.6 Trigonometry of Right Triangles

2.0 Kinematics

- *2.1 Measurement Quantities
  - 2.1.1 Scalar
  - 2.1.2 Vector
  - 2.1.3 Δt
- 2.2 Analysis of Vectors
  - *2.2.1 Addition
  - 2.2.2 Subtraction
  - 2.2.3 Components
- 2.3 Speed
  - *2.3.1 Calculation from a distance vs. time graph
  - 2.3.2 Average value: $\bar{v} = s/t$
  - 2.3.3 Vector/ Velocity
  - 2.3.4 Scalar
  - +2.3.5 Experimental determination
- 2.4 Acceleration
  - *2.4.1 Calculation from a speed vs. time graph
  - *2.4.2 Definition: $a = \Delta v/t$
  - *2.4.3 $g = 9.8 \frac{m}{s^2}$
  - +2.4.4 Experimental determination
- 2.5 Distance
  - 2.5.1 Scalar
  - *2.5.2 Calculation: $s = vt$
  - 2.5.3 Vector/ Displacement
  - *2.5.4 Calculation from a speed vs. time graph
- 2.6 Projectiles
  - 2.6.1 Horizontal/ Vertical components
  - 2.6.2 Independence of components
- 2.7 Projectile Motion Analysis

3.0 Dynamics

- 3.1 Newton's Laws
  - 3.1.1 Inertia
  - *3.1.2 First Law
  - *3.1.3 Second Law
  - 3.1.4 Third Law
  - 3.1.5 Frame of reference

* Indicates Minimum Level Skills
\+ Indicates Laboratory Skills

PHYSICS I

- *3.2 Weight
  - 3.2.1 Comparison with mass
  - 3.2.2 Computation
- 3.3 Force
  - *3.3.1 Definition
  - 3.3.2 Net force
  - *3.3.3 Units
  - *3.3.4 Calculation of F, m, or a: $F = ma$
  - +3.3.5 $F = ma$ verification
- 3.4 Momentum
  - 3.4.1 Impulse
  - 3.4.2 Units
  - *3.4.3 Conserved
  - *3.4.4 mv
  - *3.4.5 Calculation: mv
  - 3.4.6 Collision justification
  - +3.4.7 Experimental application

4.0 Energy

- 4.1 Work
  - *4.1.1 Definition
  - 4.1.2 Calculation: Fs
  - 4.1.3 Units
- 4.2 Potential Energy
  - *4.2.1 Definition
  - 4.2.2 mgh
  - 4.2.3 Gravitational potential
  - 4.2.4 Units
- *4.3 Kinetic Energy
  - 4.3.1 Definition
  - 4.3.2 $1/2\ mv^2$
  - 4.3.3 Units
- 4.4 Pendulum
  - *4.4.1 Maximum kinetic energy
  - 4.4.2 Maximum potential energy
  - 4.4.3 Minimum potential energy
- 4.5 Mass/Energy
- 4.6 Power
  - 4.6.1 Definition
  - 4.6.2 Work ÷ time
  - 4.6.3 Watt

5.0 Specific Forces

- 5.1 Circular
  - 5.1.1 Acceleration vector direction
  - *5.1.2 Force vector direction
  - *5.1.3 Acceleration: $a = v^2/R$
  - 5.1.4 Instantaneous velocity direction
- 5.2 Simple Harmonic Motion
  - *5.2.1 Example
  - +5.2.2 Hooke's Law application
  - *5.2.3 Rest position/ Equilibrium position
  - 5.2.4 Maximum force position
  - 5.2.5 Minimum force position
  - 5.2.6 Maximum acceleration position
  - 5.2.7 Minimum acceleration position
  - 5.2.8 Maximum velocity position
  - *5.2.9 Period: $T = 2\pi\sqrt{\ell/g}$
  - +5.2.10 Period
  - *5.2.11 Frequency: $f = 1/T$
  - 5.2.12 Minimum velocity position
- 5.3 Universal Gravitation
  - *5.3.1 $F = GmM/R^2$
  - 5.3.2 Calculation for two spheres

PHYSICS I

6.0 Waves

- 6.1 Longitudinal
  - *6.1.1 Identification
  - 6.1.2 Compression
  - +6.1.3 Observation
  - 6.1.4 Rarefaction
- 6.2 Transverse
  - *6.2.1 Identification
  - 6.2.2 Comparison to longitudinal
  - *6.2.3 Water waves
  - +6.2.4 Observations
- *6.3 Sound: Longitudinal Wave
- 6.4 Terminology
  - *6.4.1 Wavelength
  - 6.4.2 Frequency
  - *6.4.3 Amplitude
  - 6.4.4 Period
- 6.5 Velocity
  - *6.5.1 $v = f\lambda$
  - 6.5.2 Calculation
- 6.6 Properties of Waves
  - 6.6.1 Standing waves
  - 6.6.2 Superposition
  - +6.6.3 Observation: standing wave
  - +6.6.4 Observation: superposition
  - +6.6.5 Observation: reflection, refraction, diffraction

7.0 Electricity

- 7.1 Electrostatics
  - *7.1.1 Reaction of like charges
  - *7.1.2 Reaction of unlike charges
  - 7.1.3 Methods of charging
  - 7.1.4 Coulomb's Law
  - 7.1.5 Insulators
  - 7.1.6 Conductors
  - +7.1.7 Observation of charge reaction
  - +7.1.8 Electrification of an object
  - +7.1.9 Test for electrical conduction
- *7.2 Current Electricity
  - 7.2.1 Volt
  - 7.2.2 Ampere
  - 7.2.3 Resistance
- 7.3 Circuits
  - *7.3.1 Series
  - 7.3.2 Parallel
  - 7.3.3 Resistance calculation
  - *7.3.4 Ohm's Law application
  - +7.3.5 Construction of a series circuit
  - +7.3.6 Construction of a parallel circuit
  - +7.3.7 Ohm's Law usage
  - +7.3.8 Voltmeter/ Ammeter usage

PHYSICS I

8.0 Heat

- 8.1 Definition/Comparison to Temperature
- 8.2 Temperature Scales
  - 8.2.1 Celsius
  - 8.2.2 Fahrenheit
  - 8.2.3 Kelvin
- 8.3 Laws of Thermodynamics
  - 8.3.1 First Law
  - 8.3.2 Second Law
- 8.4 Specific Heat
- 8.5 Latent Heat
  - 8.5.1 Fusion
  - 8.5.2 Vaporization
- 8.6 Kinetic Theory
- +8.7 Measurement of Temperature : Heat of Fusion/Vaporization

9.0 Optics/Light

- 9.1 Electromagnetic Spectrum
- 9.2 Speed of Light
- 9.3 Wave Behavior
  - 9.3.1 Propagation
  - 9.3.2 Reflection
  - 9.3.3 Refraction
  - 9.3.4 Snell's Law
  - 9.3.5 Interference
  - 9.3.6 Huygen's Principle
- +9.4 Experimentation
  - 9.4.1 Reflection
  - 9.4.2 Refraction
  - 9.4.3 Interference
- 9.5 Lenses/Mirrors
  - 9.5.1 Converging mirrors
  - 9.5.2 Plane mirrors
  - 9.5.3 Diverging mirrors
  - 9.5.4 Converging lenses
  - 9.5.5 Diverging lenses
- 9.6 Ray Diagrams
  - 9.6.1 Mirrors
  - 9.6.2 Lenses

10.0 Modern Physics

- 10.1 History
- 10.2 Black Body Radiation
- 10.3 Photoelectric Effect
- 10.4 Calculation, $E = hf$
- 10.5 Compton Effect
- 10.6 Rutherford Experiments
- 10.7 Bohr Atom
- 10.8 de Broglie Wavelength

PERFORMANCE OBJECTIVES
PHYSICS I

To demonstrate the ability to recall and apply knowledge of measurement and graphing, kinematics, dynamics, energy, specific forces, waves, electricity, heat, optic-light, and modern physics; students will master the performance objectives listed below. Successful completion of this course is based on teacher judgement and the requirement that students pass the Minimum Level Skills Test.

Performance Objectives

1.0 Measurement and Graphing

1.1 To demonstrate knowledge of metric units when given a list of MKS and cgs units, students will:

(1) select the unit of length (meter);

(2) select the unit of area;

(3) select the unit of volume;

*(4) select the unit of mass (kilogram);

(5) select the unit of time;

+(6) measure length using metric units; and

+(7) measure mass using metric units.

*1.2 To demonstrate knowledge of metric conversions, students will (1) convert a measurement in centimeters to a measurement in meters; and (2) identify the statement that 10 millimeters = 1 centimeter.

*1.3 To demonstrate knowledge of metric prefixes, students will identify the meaning of the following metric prefixes:

(1) kilo-;

(2) centi-; or

(3) milli-.

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* Indicates Minimum Level Skills
\+ Indicates Laboratory Skills

*1.4 From a list of numbers, students will select the number correctly written in scientific notation.

1.5 To demonstrate knowledge of the use of graphs, students will:

*(1) match values on a direct variation graph (line);

(2) match values on an inverse variation graph (hyperbola); and

+(3) construct graphs using experimentally obtained data.

1.6 Students will find the sines, cosines, and tangents of the acute angles of right triangles.

2.0 Kinematics

*2.1 To demonstrate knowledge of measurement quantities students will:

(1) select speed and distance as scalar quantities;

(2) select velocity and displacement as vector quantities; and

(3) identify $\Delta t = t_f - t_0$.

2.2 To demonstrate knowledge of vector analysis, when given two perpendicular vectors and their resultant, students will identify the resultant when:

*(1) the vectors (head to tail) are added;

(2) the vectors (tail to tail) are subtracted; and

(3) the resultant is the vector whose components are the perpendicular vectors.

2.3 To demonstrate knowledge of speed, students will:

*(1) calculate speed from a distance as a function of time graph;

(2) identify $\bar{v} = s/t$ as the average value of speed;

(3) identify velocity as a vector quantity;

(4) identify speed as a scalar quantity; and

+(5) construct and analyze a distance as a function of time graph using experimental data.

2.4 To demonstrate knowledge of acceleration, students will:

*(1) calculate acceleration from a speed as a function of time graph;

*(2) define acceleration as $a = \Delta v/t$;

*(3) Identify $g = 9.8\ m/s^2$ as the approximate value (MKS system) for the acceleration of gravity at the earth's surface if gravity is the only force acting; and

+(4) construct and analyze a velocity as a function of time graph using experimental data.

2.5 To demonstrate knowledge of distance, students will:

(1) identify distance as a scalar quantity;

*(2) calculate distance traveled using $s = \bar{v}t$ when given $\bar{v}$ and t;

(3) identify displacement as a vector quantity; and

*(4) calculate distance traveled from a speed as a function of time graph.

2.6 To demonstrate knowledge of projectiles, students will:

(1) identify horizontal and vertical components; and

(2) state that the horizontal and vertical components are independent.

2.7 Students will analyze projectile motion.

3.0 Dynamics

3.1 To demonstrate knowledge of Newton's Laws, students will:

(1) define inertia as resistance to motion;

*(2) define Newton's first law as the law stating that an object in motion remains in motion unless acted upon by a net external force;

*(3) define Newton's second law by the relationship $F = ma$;

(4) apply Newton's third law to a situation such as walking; and

(5) identify the frame of reference applicable to Newton's laws (inertial).

*3.2 To demonstrate knowledge of weight, students will (1) compare weight to mass identifying mass as unchanged by location; and (2) compute the weight of an object using $W = mg$ when given $g = 10\ m/s^2$.

3.3 To demonstrate knowledge of force, students will:

*(1) define force as that which can cause acceleration of a mass;

(2) identify net force as unbalanced force;

*(3) identify the MKS unit for force as the newton (N);

*(4) calculate force, mass, or acceleration using Newton's second law ($F = ma$); and

+(5) verify Newton's second law ($F = ma$) experimentally.

3.4 To demonstrate knowledge of momentum, students will:

(1) define impulse as $Ft = m\Delta v$;

(2) identify the units of momentum in the MKS system as kg-m/s;

*(3) state that momentum is conserved in all collisions;

*(4) identify mv as momentum;

*(5) calculate momentum using mv;

(6) justify the velocities of two spheres in a one dimensional collision using the conservation of momentum; and

+(7) observe and describe momentum situations.

4.0 Energy

4.1 To demonstrate knowledge of work, students will:

*(1) define work as Fs;

(2) calculate the work done using Fs; and

(3) identify N-m or Joule as the units of work in the MKS system of measurement.

4.2 To demonstrate knowledge of potential energy, students will:

*(1) define potential energy as energy a body has due to its position or location;

(2) identify potential energy as mgh;

(3) identify gravitational potential as the energy a body has due to its position relative to the earth; and

(4) identify N-m or Joule as the units of potential energy in the MKS system of measurement.

*4.3 To demonstrate knowledge of kinetic energy, students will:

(1) define kinetic energy as the energy an object posseses due to its motion;

(2) identify $1/2\ mv^2$ as the formula for kinetic energy; and

(3) identify N-m or Joule as the units of kinetic energy in the MKS system of measurement.

4.4 To demonstrate knowledge of a pendulum, students will:

*(1) identify the position of maximum kinetic energy when given a diagram of a pendulum;

(2) identify the position of maximum potential energy when given a diagram of a pendulum; and

(3) identify the position of minimum potential energy when given a diagram of a pendulum.

4.5 Students will relate mass to energy and state that mass and energy are conserved.

4.6 To demonstrate knowledge of mechanical power, students will:

(1) define power as the rate at which work is done;

(2) identify power as work divided by time; and

(3) identify watt as a unit of power.

5.0 Specific Forces

5.1 To demonstrate knowledge of circular motion, students will:

(1) identify the circular acceleration vector when given a vector diagram of circular motion;

*(2) identify the circular force vector when given a vector diagram of circular motion;

*(3) define circular acceleration as $a = v^2/R$; and

(4) identify the instantaneous velocity from a vector diagram of circular motion.

5.2 To demonstrate knowledge of simple harmonic motion, students will:

*(1) identify a diagram of a vibrating mass on a spring as an example of simple harmonic motion;

+(2) identify Hooke's law as $F = -kx$ when experimentally applied to a spring;

*(3) identify the rest or equilibrium position in simple harmonic motion from a diagram;

(4) identify the maximum force position in simple harmonic motion;

(5) identify the minimum force position in simple harmonic motion;

(6) identify the maximum acceleration position in simple harmonic motion;

(7) identify the minimum acceleration position in simple harmonic motion;

(8) identify the maximum velocity position in simple harmonic motion;

*(9) identify the period of a pendulum as $T = 2\pi\sqrt{\ell/g}$;

+(10) measure the period of a pendulum;

*(11) identify the relationship between frequency and period as $f = 1/T$; and

(12) identify the minimum velocity position in simple harmonic motion.

5.3 To demonstrate knowledge of universal gravitation, students will:

*(1) identify $F = GmM/R^2$ as the universal gravitation equation; and

(2) calculate the gravitational force for two spheres.

6.0 Waves

6.1 To demonstrate knowledge of longitudinal waves, students will:

*(1) identify the longitudinal wave when given a diagram of a longitudinal wave and a transverse wave;

(2) define compressions as regions of compressed material as a longitudinal wave moves through that material;

+(3) observe longitudinal waves; and

(4) define rarefaction as regions of rarefied materials as a longitudinal wave moves through that material.

6.2 To demonstrate knowledge of transverse waves, students will:

*(1) identify the transverse wave when given a diagram of a longitudinal wave and a transverse wave;

(2) compare transverse waves with longitudinal waves;

*(3) identify surface water waves as transverse waves; and

+(4) observe transverse waves.

*6.3 Students will identify sound as a longitudinal wave.

6.4 To demonstrate knowledge of wave terminology when given a wave form graph (transverse wave), students will:

*(1) identify the wavelength (of a transverse wave);

(2) identify the frequency;

*(3) identify the amplitude (of a transverse wave); and

(4) identify the period.

6.5 To demonstrate knowledge of wave velocity, students will:

*(1) identify $v = f\lambda$ as the wave velocity; and

(2) calculate the wave velocity using $v = f\lambda$.

6.6 To demonstrate knowledge of the properties of waves, students will:

(1) identify standing waves;

(2) identify superposition (interference);

+(3) observe standing waves;

+(4) observe superposition (interference); and

+(5) observe reflection, refraction, and diffraction.

7.0 Electricity

7.1 To demonstrate knowledge of electrostatics, students will:

*(1) identify the reaction of like electrostatic charges;

*(2) identify the reaction of unlike electrostatic charges;

(3) identify methods of charging;

(4) identify Coulomb's Law as $F = k\frac{qQ}{R^2}$;

(5) identify insulators in a list of materials;

(6) identify conductors in a list of materials;

+(7) observe the reactions of like and unlike electrostatic charges;

+(8) charge an object by contact, friction, or induction; and

+(9) record the results of the testing of materials for electrical conduction.

*7.2 To demonstrate knowledge of current electricity, students will select statements that identify :

(1) voltage as potential difference;

(2) amperage as current; and

(3) resistance as the ratio of voltage to electric current.

7.3 To demonstrate knowledge of circuits when given diagrams of simple circuits, students will:

*(1) identify series circuits;

(2) identify parallel circuits;

(3) calculate the total resistance in the series and parallel circuits;

*(4) apply Ohm's Law (V = IR) to find circuit voltage given the circuit amperage and total resistance of the circuit;

+(5) construct a series circuit;

+(6) construct a parallel circuit;

+(7) use Ohm's Law in a simple circuit wired by the student; and

+(8) use a voltmeter or an ammeter in a simple circuit.

8.0 Heat

8.1 Students will identify the definition of heat and distinguish heat from temperature.

8.2 To demonstrate knowledge of temperature scales, students will convert given temperature measurements from one temperature scale to other temperature scales using

(1) Celsius;

(2) Fahrenheit; or

(3) kelvin.

8.3 To demonstrate knowledge of the laws of thermodynamics, students will apply (1) the first law of thermodynamics; and (2) the second law of thermodynamics to appropriate examples.

8.4 Given the heat, mass, and temperature change for a substance, students will calculate the specific heat of the substance.

8.5 To demonstrate knowledge of latent heat, students will identify a definition for latent heat of (1) fusion; and (2) vaporization.

8.6 Students will identify a statement describing the Kinetic Theory of gases.

+8.7 Students will experimentally measure temperature using a Celsius thermometer, the heat of fusion of ice, the heat of vaporization of water indirectly, or the specific heat of a substance.

9.0 Optics-Light

9.1 Students will identify a statement that describes the electromagnetic spectrum.

9.2 Students will identify the speed of light.

9.3 To demonstrate knowledge of the wave behavior of light, students will:

(1) identify a description of propagation of light;

(2) identify a description of reflection of light;

(3) identify a description of refraction of light;

(4) apply Snell's Law to determine the angle of refraction;

(5) identify a diagram of interference; and

(6) apply Huygen's Principle to predict the direction of wave propagation.

+9.4 To demonstrate knowledge of light wave behavior, students will:

(1) verify that the angle of reflection equals the angle of incident;

(2) demonstrate refraction; and

(3) observe interference (light or water waves).

9.5 To demonstrate knowledge of mirrors and lenses, students describe:

(1) converging mirrors;

(2) plane mirrors;

(3) diverging mirrors;

(4) converging lenses; and

(5) diverging lenses.

9.6 To demonstrate knowledge of the use of ray diagrams to locate images, students will draw ray diagrams of

(1) plane, converging, and diverging mirrors; and

(2) converging and diverging lenses.

10.0 Modern Physics

10.1 Students will list conditions leading to the development of modern physics.

10.2 Students will state the significance of black body radiation.

10.3 Students will describe the photoelectric effect.

10.4 Students will calculate quantized energy using $F = hf$.

10.5 Students will describe the Compton Effect.

10.6 Students will state Rutherford's contribution to radioactivity and the model of the atom.

10.7 Students will describe the Bohr atom.

10.8 Students will describe a de Broglie wavelength.

KEY TO RECOMMENDED INSTRUCTIONAL MATERIALS

Performance Objective		Instructional Implications		Resources	
Number	Topic	Teaching Time	Tested On	County Adopted	Supplementary
1.0	Measurement and Graphing	2-3 weeks	MLST	James T. Murphy and R. Smoot, Physics Principles and Problems (Columbus, Ohio: Charles E. Merrill Publishing Company, 1977), pp. 2-11, 15-19, 24-29.	Franklin Miller Jr., et al, Concepts in Physics (Atlanta: Harcourt, Brace and Jovanovich, Inc., 1974), pp. 7-24.
2.0	Kinematics	6 weeks	MLST	Murphy, pp. 31-77, 108-14.	Miller, pp. 27-56.
3.0	Dynamics	6 weeks	MLST	Murphy, pp. 79-107.	Miller, pp. 57-76, 99-113.
4.0	Energy	4-5 weeks	MLST	Murphy, pp. 138-63.	Miller, pp. 77-98.
5.0	Specific Forces	5 weeks	MLST	Murphy, pp. 114-37.	Miller, pp. 114-48.
6.0	Waves	2-3 weeks	MLST	Murphy, pp. 220-41.	Miller, pp. 149-71.
7.0	Electricity	4 weeks	MLST	Murphy, pp. 321-71.	Miller, pp. 233-71, 286-95.

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KEY TO RECOMMENDED INSTRUCTIONAL MATERIALS

Performance Objective		Instructional Implications		Resources	
Number	Topic	Teaching Time	Tested On	County Adopted	Supplementary
8.0	Heat			Murphy, pp. 165-81, 193-94.	Miller, pp. 173-231.
9.0	Optics/Light			Murphy, pp. 243-93.	Miller, pp. 343-83.
10.0	Modern Physics			Murphy, pp. 427-51.	Miller, pp. 422-42, 452-67.

County Adopted Text:

James T. Murphy, Laboratory Physics (Columbus, Ohio: Charles E. Merrill Publishing Co., 1980).

KEY TO LABORATORY RESOURCES

Objective	Skill	County Adopted Text Pages	Other Resources
	Students will:		
+1.1.6	measure length using metric units.	Laboratory Investigation (LI) 1	Jay Walker, Physics Investigations (New York: Amsco School Publications, Inc., 1973), Experiment (E)1.
+1.1.7	measure mass using metric units.	LI 2	Walker, E 3.
+1.5.3	construct graphs using experimentally obtained data.	Introduction and applied to investigations to follow. pp. 3-4.	
+2.3.5	construct and analyze a distance as a function of time graph using experimental data.	LI 5	I. Genzer and P. Youngner, Laboratory Investigations in Physics (Atlanta: Silver Burdett, 1973), LAB 2-I and 2-II. Walker, applied to experiments to follow.
+2.4.4	construct and analyze a velocity as a function of time graph using experimental data.	LI 6	Genzer, Lab 3-I & II.

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KEY TO LABORATORY RESOURCES

Objective	Skill	County Adopted Text Pages	Other Resources
	Students will:		
+3.3.5	verify Newton's second law (F = ma) experimentally.	LI 8 and 9	Genzer, Lab 4-I. Walker, E 10.
+3.4.7	observe and describe momentum situations.	LI 10 and 11	Genzer, Lab 11-I, II. Walker, E 15 and 16.
+5.2.2	identify Hooke's Law as F = -kx when experimentally applied to a spring.	LI 17	Walker, E 7.
+5.2.10	measure the period of a pendulum.	LI 14	Genzer, Lab 12-II. Walker, E 13.
+6.1.3	observe longitudinal waves.	LI 24	Genzer, Lab 20-I.
+6.2.4	observe transverse waves.	LI 24-28	Genzer, Lab 20-I, II, III, IV, V and Lab 21-I, II, III. Walker, E 24 and 25.

KEY TO LABORATORY RESOURCES

Objective	Skill	County Adopted Text Pages	Other Resources
	Students will:		
+6.6.3	observe standing waves.	LI 26	Genzer, Lab 21-I. Walker, E 24, 25 and 26.
+6.6.4	observe superposition.	LI 24	Genzer, Lab 21-I. Walker, E 28.
+6.6.5	observe reflection, refraction, and diffraction.	LI 24, 27, 28	
+7.1.7	observe the reaction of like and unlike electrostatic charges.	LI 36	Genzer, Lab 9-II.
+7.1.8	charge an object by contact, friction, or induction.	LI 36	Genzer, Lab 9-III. Walker, E 35.
+7.1.9	record the results of the testing of materials for electrical conduction.	None	Genzer, Lab 10-IV. Walker, E 38.

KEY TO LABORATORY RESOURCES

Objective	Skill	County Adopted Text Pages	Other Resources
	Students will:		
+7.3.5	construct a series circuit.	LI 38, 39	Genzer, Lab 10-IV. Walker, E 37.
+7.3.6	construct a parallel circuit.	LI 40, 41	Genzer, Lab 10-IV. Walker, E 38.
+7.3.7	use Ohm's Law in a simple circuit wired by the student.	LI 38, 40, 41	Genzer, Lab 10-III, IV. Walker, E 39.
+7.3.8	use a voltmeter or an ammeter in a simple circuit.	LI 38, 40, 41	Genzer, Lab 10-III, IV. Walker, E 37, 38, 39.
+8.7	experimentally measure temperature using a Celsius thermometer, the heat of fusion of ice, the heat of vaporization of water indirectly, or the specific heat of a substance.	LI 18-20	Genzer, Lab 13-I, II. Walker, E 21, 22, 23.

KEY TO LABORATORY RESOURCES

Objective	Skill	County Adopted Text Pages	Other Resources
	Students will:		
+9.4.1	verify that the angle of reflection equals the angle of incident.	LI 25, 30, 33	Genzer, Lab 18-I, 20-II. Walker, E 25.
+9.4.2	demonstrate refraction.	LI 27, 31, 34	Genzer, Lab 19-I, II, 20-IV. Walker, E 26.
+9.4.3	observe interference (light or water waves).	LI 28	Genzer, Lab 21-II, III. Walker, E 28.

INTRODUCTION
PHYSICS I, ADVANCED

State Accreditator Number. .	1318
Course Code Number	2502
F.T.E. Category.	1.10
Instructional Level.	Advanced

Report Card Abbreviation . .	Phys I, Adv.
Length of Course	Year
Credit	1 Science credit
Grade Level.	11, 12

Prerequisites

Completion of Algebra II and presently taking Geometry or completion of Geometry and presently taking Algebra II.

Textbook(s)

Williams, J. E., et al, Modern Physics (New York: Holt, Rinehart and Winston Publishers, 1980).

Notes to Teachers

Changes relative to the recently-adopted textbook have been made in the content of the course outline and in the performance objectives for Physics I, Advanced. Full objectives are included in addition to the Minimum Level Skills objectives. Students are to develop laboratory and research skills as well as content knowledge.

The Minimum Level Skills (MLS) objectives are indicated with an asterisk (*), and will be the only objectives tested on the Minimum Level Skills Test (MLST). MLS objectives were changed due to the recently adopted textbook. The "Teaching Time" listed on the Key to Instructional Materials is a suggested maximum for each objective to help insure that all MLS objectives can be met by Minimum Level Skills Test time. MLS objective 7.6 can be taught using Concepts in Physics by F. Miller, Jr.

Laboratory skills are indicated with a plus sign (+). Suggested resources for teaching the laboratory skills have been listed at the end of this section of the teacher's guide. Other resources may be substituted for or added to the suggested laboratory resources.

In addition to passing the Minimum Level Skills Test, every student in this course is required to complete and present orally, at least one of the following:

A. Extensive library research

B. Laboratory experimentation

C. Extensive field study or observation

The topic to be investigated may be assigned by the teacher or selected by the student, with teacher approval. This requirement will count at least 1/4 of the grade for the third nine-week grading period. It is recommended that progress be evaluated at least once during each grading period in the first semester to insure that students are proceeding and not procrastinating.

Minimum requirements are suggested as follows:

A. A minimum of 50 hours should be spent in library research, in the field, or in the laboratory.

B. Weekly contact should be maintained between teacher and student regarding progress; students may not contact local agency personnel without teacher assistance and approval.

C. If an extensive library research project is undertaken, students will keep note cards and organize them using an outline. An abstract and bibliography, as well as the note cards and outline, are to be turned in at the time of the oral report.

D. If a laboratory or field study project is done, students will keep a log which will include established and approved procedures and data with conclusions. An abstract and bibliography as well as the log are to be turned in at the time of the oral report.

E. The abstract, outline, and bibliography are to be typed, double spaced. Warriner's English Grammar and Composition: Complete Course, Harcourt, 1977, may be used as a reference.

A guide for each requirement follows:

A. Note Cards (Required for Library Research Project)

As information is gathered, it is to be recorded on index cards. No information should be used in the project which is not on a note card. The student should keep three basic guidelines in mind: (1) no more than one main idea should be recorded on one card; (2) the source of the information, including page numbers, must be on the card; and (3) if the information is quoted directly, quotation marks must be used. The note cards can be shuffled and rearranged as the order of the project content is organized.

B. Log (Required for Laboratory or Field Project)

During investigative experimentation or field study, a dated account of all efforts made during the research, experimentation, observation, or field study is to be kept. It should be noted that a field study with a log constitutes more than a collection with classifications. In an experimental log all data should be recorded and a conclusion or conclusions should be included.

C. Bibliography (Required for All Projects)

The working bibliography is a listing, in the proper bibliographic form, of possible sources of information for the project. It is recommended that this product be done on note cards, with each entry on a separate card. It might be helpful to the student to include the location of each source (school media center, Haydon Burns Library, etc.) on each card. A minimum of ten sources is recommended, of which no more than three may be encyclopedias and at least two of which must be non-book sources (periodicals, pamphlets, audio-visual, interview, etc.). If an additional source is found after the working bibliography is submitted, that source should be approved by the teacher. The final bibliography should be submitted on paper, not note cards.

D. Abstract (Required for All Projects)

An abstract is a summary of the student's project. It is 150-200 words in length. It includes brief statements about what was done, how it was done, what was learned, limitations, and applications of the project.

E. Presentation (Required for All Projects)

The results of every student's project must be presented to an advanced class, entered in the school science fair, or other appropriate presentations. The class presentation should be a minimum of ten minutes and accompanied by visual aids (e.g., posters, films, slides, filmstrips, summary sheet, or chalkboard). These visuals should contain charts, diagrams, or graphs.

Students and teachers desiring further involvement in scientific research should use Performance Objective 13.0 as a guide.

PHYSICS I, ADVANCED

1.0 Scientific Techniques

- 1.1 Metric Units: MKS/cgs
  - 1.1.1 Length
  - 1.1.2 Area
  - 1.1.3 Volume
  - 1.1.4 Mass
  - 1.1.5 Time
- +1.2 Measurement: Length/Mass
- +1.3 Density Determination
- 1.4 Metric Prefixes
  - 1.4.1 Kilo-
  - 1.4.2 Deci-
  - 1.4.3 Centi-
  - 1.4.4 Milli-
  - 1.4.5 Mega-
  - 1.4.6 Micro-
  - 1.4.7 Nano-
- 1.5 Metric Conversions
  - 1.5.1 Centimeters/Meters
  - *1.5.2 Millimeters/Centimeters
  - 1.5.3 Kilometers/Meters
  - 1.5.4 Meters squared/Centimeters squared
  - 1.5.5 Centimeters cubed/Liters
- *1.6 Scientific Notation
- 1.7 Graphs
  - *1.7.1 Direct variation/Linear
  - *1.7.2 Inverse variation/Hyperbolic
  - +1.7.3 Construction
  - 1.7.4 Variable location
- 1.8 Trigonometry of Triangles
- 1.9 Laboratory Usage
  - 1.9.1 Safety
  - 1.9.2 Preparation
  - 1.9.3 Experimental variables
- +1.10 Laboratory Skills
  - 1.10.1 Data collection/Tabulation
  - 1.10.2 Data evaluation
  - 1.10.3 Conclusions
  - 1.10.4 Application

2.0 Kinematics

- 2.1 Measurement Quantities
  - 2.1.1 Scalar
  - 2.1.2 Vector
  - 2.1.3 Δt
  - 2.1.4 Example of scalar
  - 2.1.5 Example of vector
- 2.2 Vectors
  - *2.2.1 Addition
  - 2.2.2 Subtraction
  - *2.2.3 Components
  - 2.2.4 Equilibrant
  - +2.2.5 Observation
- 2.3 Speed
  - 2.3.1 Scalar
  - *2.3.2 Calculation from a distance vs. time graph
  - 2.3.3 Average value: $v = s/t$
  - 2.3.4 Vector/Velocity
  - 2.3.5 Instantaneous value: $v = \Delta s/\Delta t$
  - 2.3.6 Relative velocity
- +2.4 Experimental Determination: Speed
- 2.5 Acceleration
  - *2.5.1 Calculation from a velocity vs. time graph
  - *2.5.2 Definition: $a = \Delta v/\Delta t$
  - 2.5.3 $g = 9.8\ m/s^2$
- +2.6 Acceleration Experiments
  - 2.6.1 Value determination
  - 2.6.2 g's value verification

* Indicates Minimum Level Skills
\+ Indicates Laboratory Skills

PHYSICS I, ADVANCED

2.7 Distance
- 2.7.1 Scalar
- 2.7.2 Calculation: s=vt
- 2.7.3 Vector/Displacement
- *2.7.4 Calculation from a velocity vs. time graph

2.8 Equations
- 2.8.1 $s = \frac{v_i + v_f}{2} t$
- 2.8.2 $v_f^2 = v_i^2 + 2as$
- 2.8.3 $s = v_i t + \frac{1}{2} a t^2$

2.9 Problems/Object Thrown Vertically Upward
- *2.9.1 Time
- 2.9.2 Distance

2.10 Problems/Object Dropped
- 2.10.1 Velocity
- 2.10.2 Time
- *2.10.3 Distance

2.11 Projectiles
- 2.11.1 Horizontal component
- 2.11.2 Vertical component
- 2.11.3 Range
- *2.11.4 Horizontal time equals vertical time
- 2.11.5 At an angle

3.0 Dynamics

3.1 Inertia
- 3.1.1 Definition
- +3.1.2 Measurement

3.2 Newton's Laws
- *3.2.1 First law
- 3.2.2 Second law
- *3.2.3 Third law
- 3.2.4 Examples/First law
- 3.2.5 Examples/Second law
- 3.2.6 Examples/Third law
- 3.2.7 Second Law: F=ma
- *3.2.8 Frame of reference

3.3 Gravitational Mass
- 3.3.1 Definition
- 3.3.2 Gravitational mass/Inertial mass

3.4 Weight
- 3.4.1 Definition
- *3.4.2 W = mg
- 3.4.3 Mass comparison
- 3.4.4 Units: newton, dyne

3.5 Force
- 3.5.1 Definition
- 3.5.2 Net
- 3.5.3 Units
- *3.5.4 Calculation: F=ma
- +3.5.5 Verification/F=ma

4.0 Energy

4.1 Work
- 4.1.1 Definition
- *4.1.2 Force component
- 4.1.3 $W = F\Delta d$
- 4.1.4 Units: joule/erg
- 4.1.5 Mechanical energy

4.2 Power
- 4.2.1 Time rate of doing work
- 4.2.2 Work divided by time
- 4.2.3 Unit: watt

4.3 Potential Energy
- 4.3.1 Definition
- *4.3.2 Gravitational potential
- *4.3.3 $PE = mg\Delta h$
- 4.3.4 Units: Joule/erg

PHYSICS I, ADVANCED

- 4.4 Kinetic Energy
  - 4.4.1 Definition
  - 4.4.2 Units
  - *4.4.3 $KE = \frac{1}{2}mv^2$
  - 4.4.4 Comparison to potential energy
- 4.5 Pendulum: Energy Relationships/Positions
  - 4.5.1 Maximum kinetic energy
  - 4.5.2 Maximum potential energy
  - 4.5.3 Minimum potential energy
  - 4.5.4 Minimum kinetic energy
- 4.6 Mass/Energy: Relativity
  - 4.6.1 Mass conservation
  - 4.6.2 Energy conservation
  - 4.6.3 Mass relation to energy
  - 4.6.4 Equation: $\Delta E = (\Delta m)c^2$
  - 4.6.5 Calculation: relativistic energy
  - 4.6.6 Calculation: relativistic mass
- 4.7 Relativistic Length/Time
  - 4.7.1 Length equation
  - 4.7.2 Time equation
  - 4.7.3 Length contraction
  - 4.7.4 Time dilation

5.0 Momentum/Mass Times Velocity

- *5.1 Calculation: mv
- 5.2 Units of Momentum
- 5.3 Impulse
  - 5.3.1 Definition: Ft
  - *5.3.2 Calculation
  - 5.3.3 Units
- 5.4 Conservation
  - 5.4.1 One dimension collisions
  - 5.4.2 Two dimension collisions
  - *5.4.3 All collisions
  - 5.4.4 Gain equals loss
- *5.5 Elastic vs. Inelastic Collisions
- +5.6 Observation of Elastic/ Inelastic Collisions
- 5.7 Center of Mass

6.0 Uniform Circular Motion/ Gravitation

- 6.1 Circular Motion/ Centripetal Acceleration
  - 6.1.1 $a = v^2/R$
  - 6.1.2 $a = 4\pi^2R/T^2$
  - 6.1.3 Direction
- 6.2 Uniform Circular Motion/ Centripetal Force
  - *6.2.1 Direction
  - *6.2.2 $F = mv^2/R$
  - *6.2.3 Instantaneous velocity direction
  - 6.2.4 Fictitious centrifugal force
  - +6.2.5 Observations
- 6.3 Universal Gravitation
  - 6.3.1 Equation
  - *6.3.2 Calculation for two spheres
  - 6.3.3 Application to satellites
  - 6.3.4 Application of g's value
  - 6.3.5 Weightlessness

7.0 Simple Harmonic Motion

- 7.1 Examples
- +7.2 Hooke's Law
- 7.3 Reference Circle

PHYSICS I, ADVANCED

- *7.4 Acceleration or Force Displacement
- 7.5 Maximum Velocity as $v = 2\pi A/T$
- *7.6 Period as $T = 2\pi\sqrt{m/k}$
- 7.7 Potential Energy = $\frac{1}{2}k(\Delta d)^2$
- 7.8 Pendulum
  - 7.8.1 Period derivation
  - 7.8.2 Period equation
  - *7.8.3 Period calculation
  - 7.8.4 Limitations
  - 7.8.5 Equilibrium position
  - 7.8.6 Maximum force/ Maximum acceleration position
  - 7.8.7 Minimum force/ Minimum acceleration position
  - 7.8.8 Maximum velocity position
  - 7.8.9 Minimum velocity position
  - *7.8.10 Mass effect on period
  - +7.8.11 Period measurement

8.0 Wave Motion

- 8.1 Pulses
- 8.2 Longitudinal Waves
  - *8.2.1 Identification
  - 8.2.2 Compression
  - 8.2.3 Rarefaction
  - 8.2.4 Example/Sound
  - +8.2.5 Observation
- 8.3 Transverse Waves
  - 8.3.1 Identification
  - 8.3.2 Comparison to longitudinal
  - 8.3.3 Example/Surface water waves
  - +8.3.4 Observation
- 8.4 Terminology
  - 8.4.1 Wavelength
  - 8.4.2 Frequency
  - 8.4.3 Amplitude
  - 8.4.4 Period
  - *8.4.5 Frequency: $f = 1/T$
- 8.5 Velocity
  - 8.5.1 $v = f\lambda$
  - *8.5.2 Calculation
- 8.6 Properties of Waves
  - 8.6.1 Standing waves
  - 8.6.2 Superposition principle
  - 8.6.3 Interference pattern
  - *8.6.4 Nodes
  - 8.6.5 Antinodes
  - 8.6.6 Doppler Effect
  - +8.6.7 Observation

9.0 Electromagnetism

- 9.1 Electrostatics
  - 9.1.1 Reaction of charges
  - 9.1.2 Methods of charging
  - *9.1.3 Coulomb's Law
  - *9.1.4 Charge conservation
- +9.2 Electrostatic Laboratory
  - 9.2.1 Observations
  - 9.2.2 Charge on objects
- 9.3 Current Electricity Terms
  - *9.3.1 Volt
  - *9.3.2 Ampere/Current
  - 9.3.3 Resistance
  - 9.3.4 Coulomb
  - 9.3.5 Electromotive force/emf
  - 9.3.6 Power
  - 9.3.7 Resistivity
  - 9.3.8 Resistivity equation

PHYSICS I, ADVANCED

- 9.4 Joule's Law
  - 9.4.1 Equation
  - *9.4.2 Calculation
- 9.5 Electric Fields
  - *9.5.1 Intensity as $\xi = F/Q$
  - *9.5.2 Direction of lines of force
  - 9.5.3 Electric Potential as $\xi = \Delta v/\Delta s$
- 9.6 Capacitance
  - 9.6.1 As $C = Q/V$
  - 9.6.2 Construction/ Function
  - 9.6.3 Dialectic constant
  - 9.6.4 Parallel
  - 9.6.5 Series
- 9.7 Circuits
  - 9.7.1 Series definition
  - 9.7.2 Parallel definition
  - *9.7.3 Ohm's Law usage
  - *9.7.4 Series resistance
  - 9.7.5 Parallel resistance
  - 9.7.6 $E = V \pm Ir$ usage
  - +9.7.7 Construction: series, parallel circuits
  - +9.7.8 Voltmeter/Ammeter usage
- 9.8 Magnetism
  - *9.8.1 Definition
  - 9.8.2 Field strength as $B = F/Qv$
  - 9.8.3 Field strength as $B = F/I\Delta\ell$
  - 9.8.4 Current loops
  - 9.8.5 Hand rules
  - +9.8.6 Map magnetic fields
  - 9.8.7 Field strength as $B = 2kI/r$
  - 9.8.8 Earth's magnetism
  - +9.8.9 Tangent galvanometer
  - 9.8.10 Induced emf as $E = B\ell v$
  - 9.8.11 Lenz's Law
- 9.9 Electromagnetic Radiation
  - 9.9.1 Electromagnetic wave
  - 9.9.2 Spectrum

10.0 Heat

- 10.1 Definition
- 10.2 Temperature Definition
- 10.3 Heat vs. Temperature
- 10.4 Temperature Scales
  - 10.4.1 Celsius
  - 10.4.2 Fahrenheit
  - 10.4.3 Kelvin
- 10.5 Laws of Thermodynamics
  - 10.5.1 First
  - 10.5.2 Second
- 10.6 Specific Heat
  - 10.6.1 Definition
  - 10.6.2 $Q = mc\Delta T$
- 10.7 Latent Heat
  - 10.7.1 Fusion
  - 10.7.2 $Q = h_f m$
  - 10.7.3 Vaporization
  - 10.7.4 $Q = h_v m$
- 10.8 Mechanical Equivalent of Heat
- 10.9 Ideal Gases
  - 10.9.1 Assumptions
  - 10.9.2 Boyle's Law
  - 10.9.3 P/T = constant
  - 10.9.4 $PV = nRT$
- +10.10 Measure Temperature/Heat of Fusion or Vaporization/ Specific Heat

PHYSICS I, ADVANCED

- 11.0 Optics/Light
  - 11.1 Wave Behavior
    - 11.1.1 Huygen's Principle
    - 11.1.2 Propagation
    - 11.1.3 Reflection
    - 11.1.4 Refraction
    - 11.1.5 Index of refraction
    - 11.1.6 Snell's Law
    - 11.1.7 Interference
  - 11.2 Lenses
    - 11.2.1 Thin
    - +11.2.2 Ray Diagrams
    - 11.2.3 Convex
    - 11.2.4 Concave
    - 11.2.5 Magnification
  - 11.3 Mirrors
    - 11.3.1 Plane
    - 11.3.2 Concave
    - 11.3.3 Convex
  - +11.4 Experiments
    - 11.4.1 Reflection
    - 11.4.2 Refraction
    - 11.4.3 Interference
- 12.0 Modern/Nuclear
  - 12.1 Modern History
    - 12.1.1 Development
    - 12.1.2 Max Planck
    - 12.1.3 Einstein
  - 12.2 Photoelectric Effect
    - 12.2.1 Description
    - 12.2.2 Photon
    - 12.2.3 E = hf
  - 12.3 Compton Effect
    - 12.3.1 Description
    - 12.3.2 Wave/Particle duality
    - 12.3.3 de Broglie wavelength
  - 12.4 Bohr Atom
  - 12.5 Nuclear (History)
    - 12.5.1 Radioactive decay
    - 12.5.2 Particle detectors
    - 12.5.3 Particle accelerators
    - 12.5.4 Fission
    - 12.5.5 Fusion
- 13.0 Scientific Method
  - 13.1 Problem Statement
  - 13.2 Problem or Topic Research
    - 13.2.1 Resource books
    - 13.2.2 Periodicals
    - 13.2.3 Textbooks
  - 13.3 Controls Set-Up
  - 13.4 Variables Identification
    - 13.4.1 Controls
    - 13.4.2 Independent
    - 13.4.3 Dependent
  - 13.5 Controls Set-Up
  - 13.6 Procedure Arrangement
  - 13.7 Implementation of Procedure
  - 13.8 Collection/Tabulation of Data
  - 13.9 Results' Evaluation
  - 13.10 Conclusions
  - 13.11 Conclusions' Application

PERFORMANCE OBJECTIVES
PHYSICS I, ADVANCED

To demonstrate the ability to recall and apply knowledge of scientific techniques, kinematics, dynamics, energy, momentum, circular motion and gravitation, simple harmonic motion, wave motion, electromagnetism, heat, optics-light, modern and nuclear physics, and scientific method; students will master the performance objectives listed below. Successful completion of this course is based on teacher judgement and the requirement that students pass the Minimum Level Skills Test.

Performance Objectives

1.0 Scientific Techniques

1.1 To demonstrate knowledge of metric units, students will:

(1) identify the unit of length as the meter;

(2) identify the unit of area as meter squared;

(3) identify the units of volume as the liter;

(4) identify the unit of mass as the kilogram; and

(5) identify the unit of time as the second.

+1.2 Students will measure length using a meterstick, ruler, micrometer, or vernier caliper; measure mass using a balance; and measure time.

+1.3 Students will determine density using volume and mass measurements of a substance obtained experimentally.

1.4 To demonstrate knowledge of metric prefixes, students will:

(1) identify the meaning of kilo-;

(2) identify the meaning of deci-;

(3) identify the meaning of centi-;

(4) identify the meaning of milli-;

(5) identify the meaning of mega-;

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* Indicates Minimum Level Skills
\+ Indicates Laboratory Skills

*(6) identify the meaning of micro-; and

(7) identify the meaning of nano-.

1.5 To demonstrate knowledge of metric conversions, students will:

(1) convert measurements in centimeters to meters and measurements in meters to centimeters;

*(2) convert measurements in millimeters to centimeters and measurements in centimeters to millimeters;

(3) convert measurements in kilometers to meters and measurements in meters to kilometers;

(4) convert measurements in meters squared to centimeters squared and measurements in centimeters squared to meters squared; and

(5) convert measurements in centimeters cubed to liters and measurements in liters to centimeters cubed.

*1.6 Students will select numbers written in scientific notation, when given a list of numbers.

1.7 To demonstrate knowledge of graphs, students will:

*(1) identify direct variation graphs (linear);

*(2) identify inverse variation graphs (hyperbolic);

+(3) construct graphs from experimentally obtained data; and

(4) locate corresponding variables when given a graph.

1.8 Students will find sines, cosines, and tangents of the acute angles of right triangles and will use the law of cosines and law of sines to solve acute triangles.

1.9 To demonstrate knowledge of laboratory usage, students will:

(1) state the safety rules for the laboratory they are using;

(2) outline the steps in laboratory preparation; and

(3) identify the experimental variables in a given investigation.

+1.10 To demonstrate knowledge of laboratory skills, students will:

(1) collect and tabulate experimental data;

(2) evaluate experimental data;

(3) draw conclusions based on experimental data; and

(4) apply concepts from research to conclusions.

2.0 Kinematics

2.1 To demonstrate knowledge of measurement quantities, students will:

(1) define a scalar quantity as one which requires a magnitude measurement only;

(2) define a vector quantity as one which requires a magnitude and a direction measurement;

(3) identify $\Delta t = t_f - t_i$;

(4) name speed and distance as scalar quantities; and

(5) name velocity and displacement as vector quantities.

2.2 To demonstrate knowledge of vectors, students will:

*(1) identify the resultant when vectors are added,

(2) identify the resultant when vectors are subtracted,

*(3) identify the components of a vector,

(4) identify the equilibrant of a vector or vectors, and

+(5) observe vectors (force) acting on a system.

2.3 To demonstrate knowledge of speed, students will:

(1) identify speed as a scalar quantity;

*(2) calculate speed from a distance as a function of time graph;

(3) identify the average value of speed as $v = s/t$;

(4) identify velocity as a vector quantity;

(5) identify the instantaneous value of speed as $v = \Delta s/\Delta t$; and

(6) determine the relative velocity in a motion situation.

+2.4 Students will construct and analyze a distance as a function of time graph using experimental data (determine speed).

2.5 To demonstrate knowledge of acceleration, students will:

*(1) calculate acceleration from a velocity as a function of time graph;

*(2) define acceleration as $a = \Delta v/\Delta t$; and

(3) state acceleration due to gravity as $g = 9.8\ m/s^2$.

+2.6 To demonstrate knowledge of laboratory determination of acceleration, students will:

(1) construct and analyze a velocity as a function of time graph using experimental data (determine acceleration); and

(2) verify $g = 9.8\ m/s^2$.

2.7 To demonstrate knowledge of distance, students will:

(1) recognize distance as a scalar quantity;

(2) calculate distance by $s = vt$;

(3) recognize displacement as a vector quantity; and

*(4) calculate distance traveled from a velocity as a function of time graph.

2.8 To demonstrate knowledge of equations involving several variables, students will solve motion problems involving the use of the following equations:

(1) $s = \frac{v_i + v_f}{2}\ t$;

(2) $v_f^2 = v_i^2 + 2as$; and

(3) $s = v_i t + \frac{1}{2}at^2$.

2.9 To demonstrate knowledge of problem solving, students will solve problems involving the motion of an object thrown vertically upward by calculating the value of:

*(1) the time it takes a ball to reach its maximum height; and

(2) the distance a ball will travel when thrown vertically upward.

2.10 To demonstrate knowledge of problem solving, students will solve problems (object dropped) by calculating the value of:

(1) the velocity;

(2) the time; and

*(3) the distance traveled by the object in a given time.

2.11 To demonstrate knowledge of projectiles, students will:

(1) identify the horizontal component of a projectile as uniform motion in a straight line;

(2) identify the vertical component of a projectile as uniformly accelerated motion with a = g;

(3) calculate the horizontal range of a projectile fired horizontal to the earth at a given altitude;

*(4) conclude that the horizontal time of flight equals the vertical time of flight of a projectile; and

(5) analyze the variables involved in the motion of a projectile fired at an angle.

3.0 Dynamics

3.1 To demonstrate knowledge of inertia, students will:

(1) define inertia as the tendency for all material bodies to stay at rest or, if in motion, to resist any change in their motion; and

+(2) measure inertia as gravitational mass or inertial mass (inertial balance).

3.2 To demonstrate knowledge of Newton's Laws, students will:

*(1) identify Newton's first law as: an object remains at rest or in constant motion unless acted upon by a net force;

(2) identify Newton's second law as: the acceleration produced by a net force acting on an object is directly proportional to the net force and inversely proportional to the inertial mass of the object;

*(3) identify Newton's third law as: when one body exerts a force upon a second body then the second body exerts a force upon the first body of equal magnitude in the opposite direction;

(4) state an example of Newton's first law;

(5) state an example of Newton's second law;

(6) identify walking as an example of Newton's third law;

(7) identify Newton's second law as $F = ma$; and

*(8) conclude that Newton's laws of motion are true only in inertial reference frame.

3.3 To demonstrate knowledge of gravitational mass, students will:

(1) define gravitational mass as that property of matter measured on an equal arm balance; and

(2) compare gravitational mass to inertial mass.

3.4 To demonstrate knowledge of weight, students will:

(1) define weight as the force of gravity acting on a given mass;

*(2) compute weight using $W = mg$;

(3) compare weight (a force) to mass where mass does not change with location and weight does; and

(4) identify the newton (N) and dyne as units of weight.

3.5 To demonstrate knowledge of force, students will:

(1) define force as that which can cause acceleration;

(2) identify net force as the unbalanced force;

(3) identify the newton (N) and dyne as units of force;

*(4) calculate force using $F = ma$; and

+(5) verify $F = ma$ experimentally.

4.0 Energy

4.1 To demonstrate knowledge of work, students will:

(1) define work as being done when a force causes a body to be moved;

*(2) identify that the force (or component) causing work must be along the direction of motion of the work;

(3) calculate work done using $W = F\Delta d$;

(4) identify the joule (J) or erg as units of work; and

(5) describe work as a measure of the mechanical energy transferred in a system.

4.2 To demonstrate knowledge of power, students will:

(1) define power as a time rate of doing work;

*(2) identify power as work divided by time; and

(3) identify watt as a unit for power.

4.3 To demonstrate knowledge of potential energy, students will:

(1) define potential energy as energy a body has due to position or location;

*(2) identify gravitational potential energy as the energy a body has due to its position relative to the surface of the earth;

*(3) calculate the gravitational potential energy of a body ($PE = mg\Delta h$); and

(4) identify joule (J) or erg as units of potential energy.

4.4 To demonstrate knowledge of kinetic energy, students will:

(1) define kinetic energy as the energy an object has due to its speed (velocity);

(2) identify joule (J) or erg as units of kinetic energy;

*(3) calculate the kinetic energy an object has ($KE = \frac{1}{2}mv^2$); and

(4) compare the potential energy an object has to its kinetic energy as it falls freely.

4.5 To demonstrate knowledge of the energy relationships of a pendulum, students will:

(1) identify the position of maximum kinetic energy of a swinging pendulum;

(2) identify the position of maximum potential energy of a swinging pendulum;

(3) identify the position of minimum potential energy of a swinging pendulum; and

(4) identify the position of minimum kinetic energy of a swinging pendulum.

4.6 To demonstrate knowledge of mass and energy in relativity, students will:

(1) explain the conservation of mass law;

(2) explain the conservation of energy law;

(3) relate mass to energy conservation, relativistically;

(4) identify relativistic energy as $\Delta E = (\Delta m)c^2$,

(5) calculate relativistic energy using $\Delta E = (\Delta m)c^2$; and

(6) calculate relativistic mass.

4.7 To demonstrate knowledge of relativistic length and time, students will:

(1) identify the equation for relativistic length;

(2) identify the equation for relativistic time;

(3) state that length contracts relativistically; and

(4) state that time dilates relativistically.

5.0 Momentum/Mass Times Velocity

*5.1 Students will calculate momentum using mv.

5.2 Students will identify the units of momentum as kgm/s.

5.3 To demonstrate knowledge of impulse, students will:

(1) define impulse as the relationship $F\Delta t$;

*(2) calculate impulse using $F\Delta t = m\Delta v$; and

(3) identify the units of impulse as N-s.

5.4 To demonstrate knowledge of momentum conservation, students will:

(1) calculate the final velocity of an object involved in a two object, one dimensional collision using the conservation of momentum of the system;

(2) analyze a two dimensional collision using the conservation of momentum of the system;

*(3) identify that in all collisions momentum is conserved; (momentum is the only quantity that must be conserved); and

(4) recognize that the gain in momentum of one body in a system equals the loss in momentum of the other body in a system when these bodies interact.

*5.5 Students will compare elastic to inelastic collisions where energy is lost to heat, sound and/or mechanical work.

+5.6 Students will observe elastic and inelastic collisions.

5.7 Students will describe the center of mass.

6.0 Uniform Circular Motion/Gravitation

6.1 To demonstrate knowledge of centripetal acceleration students will:

(1) identify centripetal acceleration as $a = v^2/R$;

(2) identify centripetal acceleration as $a = 4\pi^2R/T^2$; and

(3) identify the direction of centripetal acceleration.

6.2 To demonstrate knowledge of centripetal force, students will:

*(1) identify the direction of centripetal force,

*(2) calculate centripetal force as $F = mv^2/R$;

*(3) identify the direction of instantaneous velocity;

(4) explain centrifugal force as a fictitious force; and

+(5) observe circular motion in the laboratory.

6.3 To demonstrate knowledge of Universal Gravitation, students will:

(1) identify the force of Universal Gravitation as $F = GmM/R^2$;

*(2) calculate the gravitational force between two spheres;

(3) apply gravitational force to satellites in circular orbit;

(4) apply gravitational force to mg and g's value; and

(5) describe weightlessness.

7.0 Simple Harmonic Motion

7.1 Students will identify examples of simple harmonic motion.

+7.2 Students will apply Hook's law experimentally to simple harmonic motion.

7.3 Students will apply the reference circle to simple harmonic motion.

*7.4 Students will state that acceleration (force) is proportional to displacement in simple harmonic motion.

7.5 Students will identify maximum velocity as $v = \frac{2\pi A}{T}$ for a spring.

*7.6 Students will identify period as $T = 2\pi\sqrt{m/k}$ for a spring.

7.7 Students will identify potential energy as $\frac{1}{2}k(\Delta d)^2$ in simple harmonic motion.

7.8 To demonstrate knowledge of the pendulum as simple harmonic motion, students will:

(1) derive the equation for the period of a pendulum;

*(2) identify the equation for the period of a pendulum;

*(3) calculate the period of a pendulum when given the length of the pendulum;

(4) state the limitations on the equation for the period of a pendulum;

(5) identify the equilibrium position of a swinging pendulum;

(6) identify the maximum force and acceleration position of a swinging pendulum;

(7) identify the minimum force and acceleration position of a swinging pendulum;

(8) identify the maximum velocity position of a swinging pendulum;

(9) identify the minimum velocity position of a swinging pendulum;

*(10) state that the mass of the pendulum bob has no effect on the period of the pendulum; and

+(11) measure the period of a pendulum.

8.0 Wave Motion

8.1 Students will define a pulse as a single disturbance such as a shock wave.

8.2 To demonstrate knowledge of longitudinal waves, students will:

*(1) identify a longitudinal wave when given a diagram of a longitudinal wave and a transverse wave;

(2) define compressions as regions of compressed material (high pressure, high density) when a longitudinal wave moves through that material;

(3) define rarefaction as a region of decreased pressure (density) when a longitudinal wave moves through a material;

(4) identify sound as an example of longitudinal waves; and

+(5) observe longitudinal waves.

8.3 To demonstrate knowledge of transverse waves, students will:

(1) identify the transverse wave when given a diagram of a longitudinal wave and a transverse wave;

(2) compare a transverse wave to a longitudinal wave;

(3) identify surface water waves as an example of transverse waves; and

+(4) observe transverse waves.

8.4 To demonstrate knowledge of the terminology of waves, students will:

(1) identify the wavelength when given a wave form diagram (transverse wave);

(2) identify the frequency of a wave in cycles per second;

(3) identify the amplitude of a wave when given a wave form diagram (transverse wave);

(4) identify the period of a wave as time required for the completion of one cycle; and

*(5) identify frequency as $f = 1/T$.

8.5 To demonstrate knowledge of the velocity of a wave, students will:

(1) identify wave velocity as $v = f\lambda$; and

*(2) calculate wave velocity using $v = f\lambda$ with f given in Hertz and λ given in meters.

8.6 To demonstrate knowledge of wave properties, students will:

(1) identify standing waves or stationary waves;

(2) apply the superposition principle to two waves using diagrams;

(3) identify an interference pattern;

*(4) define nodes as points in the wave always at rest;

(5) define antinodes as points in the wave with maximum amplitude at all times;

(6) describe the Doppler effect; and

+(7) observe standing waves and superposition in the laboratory.

9.0 Electromagnetism

9.1 To demonstrate knowledge of electrostatics, students will:

(1) identify the electrostatic reaction of two like charges or two unlike charges;

(2) identify the methods of charging objects electrostatically;

*(3) identify Coulomb's Law as $F = kqQ/R^2$; and

*(4) identify that charge is conserved during electrostatic charging of a sphere.

+9.2 To demonstrate knowledge of electrostatics in the laboratory, students will:

(1) observe electrostatic repulsion and attraction; and

(2) charge an object electrostatically.

9.3 To demonstrate knowledge of current electricity terms, students will:

*(1) define volt as work per unit charge;

*(2) identify the ampere as the rate of flow of charge;

(3) define resistance as the ratio of voltage to current;

(4) identify the Coulomb as the amount of charge flowing for one second when the current is one ampere;

(5) identify electromotive force (emf) as the energy per unit charge supplied by a nonelectric source;

(6) define electric power as I^2R or IV;

(7) identify resistivity (P) in the equation R = PL/A; and

(8) identify the equation of resistivity as R = PL/A.

9.4 To demonstrate knowledge of Joule's law, students will:

(1) state Joule's Law as R = Power/I^2; and

*(2) calculate electric power using Power = IV.

9.5 To demonstrate knowledge of electric fields, students will:

*(1) identify the electric field strength equation as $\xi = F/Q$;

*(2) identify the direction of lines of force (from positive charges to negative charges); and

(3) identify the electric field strength equation as $\xi = \Delta v/\Delta s$ (potential gradient).

9.6 To demonstrate knowledge of capacitance, students will:

(1) identify the definition of capacitance as C = Q/V;

(2) determine how a capacitor should be constructed to provide the function needed;

(3) define the dielectric constant as a ratio of capacitances;

(4) determine the capacitance of two capacitors connected in parallel; and

(5) determine the capacitance of capacitors in series.

9.7 To demonstrate knowledge of circuits, students will:

(1) define a series circuit as a circuit with one path for changes to move through;

(2) define a parallel circuit as a circuit with more than one path for charges to move through;

*(3) apply Ohm's law to a simple circuit when given the current and resistance of the circuit;

*(4) determine the total resistance of two resistors connected in series;

(5) determine the total resistance of two resistors connected in parallel;

(6) apply $E = V \pm Ir$ to a battery being charged;

+(7) construct series and parallel circuits; and

+(8) use a voltmeter to measure potential difference or an ammeter to measure electric current.

9.8 To demonstrate knowledge of magnetism, students will:

*(1) define magnetism as a force due to motion of a charged particle,

(2) identify magnetic field strength $B = F/Qv$ for moving charges;

(3) identify magnetic field strength as $B = F/I\Delta\ell$ for a current segment in a magnetic field;

(4) identify a current loop;

(5) apply left hand rule to electron flow;

+(6) map magnetic fields using a compass or iron filings;

(7) identify magnetic field strength at a distance from a current carrying wire as $B = 2kI/r$;

(8) identify a diagram of the earth's magnetic field;

+(9) use a tangent galvanometer to measure the earth's magnetic field indirectly;

(10) identify the equation for induced emf as $E = Blv$; and

(11) identify a statement of Lenz's Law.

9.9 To demonstrate knowledge of electromagnetic radiation, students will:

(1) identify an electromagnetic wave; and

(2) relate electromagnetic waves in the electromagnetic spectrum.

10.0 Heat

10.1 Students will define heat.

10.2 Students will define temperature.

10.3 Students will distinguish between heat and temperature.

10.4 To demonstrate knowledge of temperature scales, students will convert temperature measurements from one temperature scale to another temperature scale when given:

(1) Celsius;

(2) Fahrenheit; or

(3) Kelvin temperature measurements.

10.5 To demonstrate knowledge of the laws of thermodynamics, students will apply:

(1) the first law of thermodynamics; and

(2) the second law of thermodynamics to appropriate examples.

10.6 To demonstrate knowledge of specific heat, students will:

(1) define specific heat; and

(2) calculate specific heat using $Q = mc\Delta T$.

10.7 To demonstrate knowledge of latent heat, students will:

(1) define heat of fusion;

(2) calculate the heat of fusion using $Q = h_f m$;

(3) define heat of vaporization; and

(4) calculate the heat of vaporization using $Q = h_v m$.

10.8 Students will identify 4.18 Joule = 1 calorie as the mechanical equivalent of heat.

10.9 To demonstrate knowledge of ideal gases, students will:

(1) state the two assumptions made in the ideal gas laws;

(2) identify Boyle's law;

(3) identify P/T as a constant; and

(4) identify PV = nRT as the ideal gas equation.

+10.10 Students will measure temperature, heat of fusion or vaporization, or specific heat.

11.0 Optics/Light

11.1 To demonstrate knowledge of the wave behavior of light, students will:

(1) apply Huygen's Principle to predict the direction of wave propagation;

(2) identify a description of propagation of light;

(3) identify a description of reflection of light;

(4) identify a description of refraction of light;

(5) identify the index of refraction as a ratio;

(6) apply Snell's law to determine the angle of refraction; and

(7) identify a diagram as interference.

11.2 To demonstrate knowledge of lenses, students will:

(1) identify thin lenses;

+(2) draw ray diagrams;

(3) identify convex lenses;

(4) identify concave lenses; and

(5) identify magnification as a ratio.

11.3 Students will identify:

(1) a plane mirror;

(2) a concave mirror; and

(3) a convex mirror when shown each.

+11.4 To demonstrate knowledge of light reactions, students will:

(1) verify that the angle of reflection equals the angle of incident;

(2) demonstrate refraction; and

(3) observe interference (light or water waves).

12.0 Modern/Nuclear

12.1 To demonstrate knowledge of the history of modern physics, students will:

(1) list the historical conditions leading to the development of modern (quantum) physics;

(2) state Max Planck's contribution to quantum mechanics; and

(3) state Einstein's contribution to modern physics.

12.2 To demonstrate knowledge of the photoelectric effect, students will:

(1) describe the photoelectric effect;

(2) define photon; and

(3) calculate quantized energy using $E = hf$.

12.3 To demonstrate knowledge of the Compton effect, students will:

(1) describe the Compton effect;

(2) analyze the wave/particle duality of matter; and

(3) calculate a de Broglie wavelength.

12.4 Students will describe the Bohr atom.

12.5 To demonstrate knowledge of radioactivity, students will:

(1) describe radioactive decay;

(2) describe particle detectors;

(3) describe particle accelerators;

(4) define fission (nuclear); and

(5) define fusion (nuclear).

+13.0 Scientific Methods

13.1 Students will state a scientific problem from independent research.

13.2 To demonstrate knowledge of research skills, students will research a scientific problem or topic using:

(1) resource books;

(2) periodicals; and

(3) textbooks.

13.3 Students will form a hypothesis based on extensive scientific research.

13.4 To demonstrate knowledge of variables, students will identify:

(1) the controls;

(2) the independent variables; and

(3) the dependent variables of a scientific experiment.

13.5 Students will establish controls for an individual investigation.

13.6 Students will establish a procedure for an individual investigation.

13.7 Students will implement their established procedure.

13.8 Students will collect and tabulate data from experimentation done on an individual basis.

13.9 Students will evaluate experimental results.

13.10 Students will draw a conclusion or conclusions based on their results.

13.11 Students will apply their conclusion or conclusions to possible further research or experimentation.

KEY TO RECOMMENDED INSTRUCTIONAL MATERIALS

Performance Objective		Instructional Implications		Resources	
Number	Topic	Teaching Time	Tested on	County Adopted	Supplementary
1.0	Scientific Techniques	1-2 weeks	MLST	John E. Williams, et al, Modern Physics (New York: Holt, Rinehart and Winston, 1980). Williams, pp. 9, 22-25, 45-47, 616-17.	Franklin Miller Jr., et al, Concepts in Physics (Atlanta: Harcourt, Brace and Jovanovich, Inc., 1974). Miller, pp. 2-25.
2.0	Kinematics	7 weeks	MLST	Williams, pp. 33-35, 40-55, 71, 76, 90-91.	Miller, pp. 27-56.
3.0	Dynamics	5 weeks	MLST	Williams, pp. 7-9, 55-61, 64-76, 95-96.	Miller, pp. 57-76.
4.0	Energy	3 weeks	MLST	Williams, pp. 109-10, 114-15, 117-19.	Miller, pp. 77-98.
5.0	Momentum/ Mass Times Velocity	2 weeks	MLST	Williams, pp. 83, 123-29.	Miller, pp. 99-113.

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KEY TO RECOMMENDED INSTRUCTIONAL MATERIALS

Performance Objective		Instructional Implications		Resources	
Number	Topic	Teaching Time	Tested on	County Adopted	Supplementary
6.0	Uniform Circular Motion/ Gravitation	1-2 weeks	MLST	Williams, pp. 62-64, 92-97.	Miller, pp. 114-30.
7.0	Simple Harmonic Motion	2 weeks	MLST	Williams, pp. 103-108, 120-21, 143-44.	Miller, pp. 135-48. Note: MLS objective 7.6 can be taught using these pages.
8.0	Wave Motion	2-3 weeks	MLST	Williams, pp. 206-15, 224-29, 233, 239-42.	Miller, pp. 149-73.
9.0	Electro-magnetism	5-6 weeks	MLST	Williams, pp. 263-66, 354-66, 372-77, 381-84, 390, 395-406, 420-23, 433-37, 444-48, 461-64.	Miller, pp. 233-320, 343-59.
10.0	Heat			Williams, pp. 159-64, 168-77, 180-83, 191-95, 202-05.	Miller, pp. 173-231.
11.0	Optics/Light			Williams, pp. 224-26, 258-66, 291-325.	Miller, pp. 361-89.

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KEY TO RECOMMENDED INSTRUCTIONAL MATERIALS

Performance Objective		Instructional Implications		Resources	
Number	Topic	Teaching Time	Tested on	County Adopted	Supplementary
12.0	Modern/ Nuclear			Williams, pp. 266-75, 562-83.	Miller, pp. 421-71.
13.0	Scientific Method			Williams, pp. 1-6.	Research format used by: Science (Washington, D.C.: American Association For The Advancement of Science). Teacher's Guide For Senior High School, "Science Research-Physical," (Duval County Public Schools, 1978) or latest edition. Teacher originated.

J. E. Williams, et al, Modern Physics Exercises and Experiments in Physics (New York: Holt, Rinehart and Winston, 1980).

KEY TO LABORATORY RESOURCES

Objective	Skill	County Adopted Text Pages	Other Resources
	Students will:		
+1.2	measure length using a meter stick, ruler, micrometer, or venier caliper; measure mass using a balance; and measure time.	Experiments 1, 2, and 3	I. Genzer and P. Younger, Laboratory Investigations in Physics (Atlanta: Silver Burdett, 1973), Lab 1-I. James T. Murphy, Laboratory Physics (Columbus Ohio: Charles E. Merrill Publishing Co., 1972), Laboratory Investigations 1, 2 and 4. Jay Walker, Physics Investigations (New York: Amsco School Publications, Inc., 1973), Experiments 1, 3, and 4.
+1.7.3	construct graphs from experimentally obtained data.	viii and applied to investigations that follow.	Genzer, applied to investigations to follow. Murphy, pp. 3, 4 and applied to investigations to follow. Walker, applied to experiments to follow.
+1.10.1	collect and tabulate experimental data.	vii-viii	Sanford M. Eisler and Murray Stock, Lab-Inquiry Text: Physical Science (New York: Cambridge Book Company, 1972), Problems 1-2 and 1-3.

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KEY TO LABORATORY RESOURCES

Objective	Skill	County Adopted Text Pages	Other Resources
	Students will:		
+1.10.2	evaluate experimental data.	vii-viii	Eisler, Problems 1-6, 1-9.
+1.10.3	draw conclusion(s) based on experimental data.	vii-viii	Eisler, Problems 1-10.
+1.10.4	apply concept(s) from research to conclusion(s).	vii-viii	Eisler, Problems 1-10.
+2.2.5	observe vectors (force) acting on a system.	Experiments 6, 7, 9, 10	Genzer, Lab 6-I. Murphy, Laboratory Investigation 7.
+2.4	construct and analyze a distance as a function of time graph using experimental data (determine speed).	None	Genzer, Lab 2-I and 2-II. Murphy, Laboratory Investigation 5.
+2.6.1	construct and analyze a velocity as a function of time graph using experimental data (determine acceleration).	None	Genzer, Lab 3-I and 3-II. Murphy, Laboratory Investigation 6. Walker, Experiment 8

KEY TO LABORATORY RESOURCES

Objective	Skill	County Adopted Text Pages	Other Resources
	Students will:		
+2.6.2	verify $g = 9.8\ m/s^2$.	Experiment 3	Murphy, Laboratory Investigation 6.
+3.1.2	measure inertia as gravitational mass or inertial mass (inertial balance).	Experiment 2	Walker, Experiment 11.
+3.5.5	verify $F = ma$ experimentally.	Experiment 4	Genzer, Lab 4-I. Murphy, Laboratory Investigations 8-9. Walker, Experiment 10.
+5.6	observe elastic and inelastic collisions.	Experiment 17	Genzer, Laboratory 11-I, 11-II, 11-III. Murphy, Laboratory Investigations 10-11. Walker, Experiments 15-16.
+6.2.5	observe circular motion in the laboratory.	Experiment 11	Genzer, Lab 8-II. Murphy, Laboratory Investigation 13. Walker, Experiment 14.

KEY TO LABORATORY RESOURCES

Objective	Skill	County Adopted Text Pages	Other Resources
	Students will:		
+7.2	apply Hooke's law experimentally to simple harmonic motion.	Experiment 16	Murphy, Laboratory Investigation 17. Walker, Experiment 7.
+7.8.11	measure the period of a pendulum.	Experiment 13	Genzer, Lab 12-II. Murphy, Laboratory Investigation 14. Walker, Experiment 13.
+8.2.5	observe longitudinal waves.	Experiments 28, 29	Genzer, Lab 20-I. Murphy, Laboratory Investigation 24.
+8.3.4	observe transverse waves.	Experiments 28, 29	Genzer, Lab 20-I, 20-II, 20-III, 20-IV, 20-V, 21-I, 21-II, 21-III. Murphy, Laboratory Investigations 24, 25-28. Walker, Experiments 24-25.

KEY TO LABORATORY RESOURCES

Objective	Skill	County Adopted Text Pages	Other Resources
	Students will:		
+8.6.7	observe standing waves and superposition in the laboratory.	Experiment 29	Genzer, Lab 21-I. Murphy, Laboratory Investigations 24, 26. Walker, Experiments 24-26, 28.
+9.2.1	observe electrostatic repulsion and attraction.	Experiment 46	Genzer, Lab 9-II. Murphy, Laboratory Investigation 36. Walker, Experiment 35.
+9.2.2	charge an object electrostatically.	Experiment 46	Genzer, Lab 9-II. Murphy, Laboratory Investigation 36. Walker, Experiment 35.
+9.7.7	construct series and parallel circuits.	Experiments 52, 53	Genzer, Lab. 10-IV. Murphy, Laboratory Investigations 38, 39, 40, 41. Walker, Experiments 37-38.

KEY TO LABORATORY RESOURCES

Objective	Skill	County Adopted Text Pages	Other Resources
	Students will:		
+9.7.8	use a voltmeter to measure potential difference or an ammeter to measure electric current.	Experiments 49, 52-53	Genzer, Lab 10-III, 10_IV. Murphy, Laboratory Investigations 38, 40, 41. Walker, Experiments 37-39.
+9.8.6	map magnetic fields using a compass or iron filings.	Experiment 56	Genzer, Lab 10-I. Murphy, Laboratory Investigations 43, 44.
+9.8.9	use a tangent galvanometer to measure the earth's magnetic field indirectly.	None	Genzer, Lab 10-II. Murphy, Laboratory Investigation 45. Walker, Experiment 43.
+10.10	measure temperature, heat of fusion or vaporization, or specific heat.	Experiment 24-26	Genzer, Lab 13-I, 13-II. Murphy, Laboratory Investigations 18, 19, 20. Walker, Experiments 21-23.

KEY TO LABORATORY RESOURCES

Objective	Skill	County Adopted Text Pages	Other Resources
	Students will:		
+11.2.2	draw ray diagrams.	Experiments 33-35, 37, 38	Genzer, Lab 18-I, 18-II, 19-II. Murphy, Laboratory Investigation 34. Walker, Experiment 32.
+11.4.1	verify that the angle of reflection equals the angle of incident.	Experiment 33-34	Genzer, Lab 18-I, 20-II. Murphy, Laboratory Investigations 25, 30, 33. Walker, Experiment 25.
+11.4.2	demonstrate refraction.	Experiment 35	Genzer, Lab 19-I, 19-II, 20-IV. Murphy, Laboratory Investigations 22, 31, 34. Walker, Experiment 26.
+11.4.3	observe interference (light or water waves).	Experiment 29	

INTRODUCTION
PHYSICS II B, ADVANCED

State Accreditator Number. .	1329
Course Code Number	2511
F.T.E. Category.	1.10
Instructional Level.	Advanced

Report Card Abbreviation . .	Adv Physics 2 B
Length of Course	Year
Credit	1 Science credit
Grade Level.	11, 12

Prerequisites

Physics I and completion of or presently taking Trigonometry or Math Analysis; departmental approval.

Textbook(s)

Miller, Franklin, Jr., College Physics (New York: Harcourt Brace Jovanovich, Inc., 1977).

Notes to Teachers

The minimum level skills (MLS) objectives are indicated with an asterisk (*) and will be the only objectives tested on the Minimum Level Skills Test (MLST). Full course objectives are included as well as MLS. Care has been taken to match the Advanced Placement Physics B course objectives. Essential laboratory activities are indicated with an encircled plus sign ⊕. Students taking this class should be encouraged to take the Physics B, Advanced Placement Test.

PHYSICS II B, ADVANCED

1.0 Kinematics

- 1.1 One Dimension Motion
  - *1.1.1 Velocity/Time graph
  - 1.1.2 Position/Time graph
  - 1.1.3 Acceleration/Time graph
  - 1.1.4 Vertical motion graph
  - *1.1.5 Motion equations
  - ●1.1.6 Experiment analysis
- 1.2 Vectors
  - 1.2.1 Addition
  - 1.2.2 Position subtraction
  - 1.2.3 Velocity subtraction
  - *1.2.4 Components
  - 1.2.5 Vector equation
- 1.3 Projectile Motion
  - 1.3.1 Range equation
  - *1.3.2 Projectile angle
  - 1.3.3 Components
- 1.4 Circular Motion
  - 1.4.1 Centripetal acceleration equations
  - *1.4.2 Centripetal acceleration calculations
  - 1.4.3 Definition
  - 1.4.4 Centripetal acceleration directions
  - 1.4.5 Orbit speed

2.0 Newton's Laws of Motion

- 2.1 Single Body Dynamics
  - 2.1.1 Torque/Force
  - *2.1.2 Torque/Momentum
  - 2.1.3 Torque/Force equilibrium
  - *2.1.4 Static friction
  - 2.1.5 Kinetic friction
  - 2.1.6 $f = \mu N$
  - 2.1.7 Friction calculation
  - 2.1.8 Angle of repose
  - 2.1.9 Force location
  - 2.1.10 F = ma application
  - *2.1.11 F = ma = f
  - 2.1.12 Apparent weight
  - *2.1.13 $F = ma/s = v_0 t + \frac{1}{2}at^2$
  - 2.1.14 Inclined plane
  - 2.1.15 F = ma/Centripetal force
  - 2.1.16 Radius of orbit
  - 2.1.17 Banked curve
  - 2.1.18 Centripetal force/Vertical circle
  - ●2.1.19 Inertial balance
- 2.2 Dynamics: Two Or More Bodies
  - 2.2.1 Action/Reaction pair
  - 2.2.2 Tension in cord/Horizontal surface
  - 2.2.3 Atwood's machine/Acceleration calculation

3.0 Classical Mechanics: Conservation Laws

- 3.1 Energy
  - 3.1.1 Work/Energy derivation
  - *3.1.2 $W = FsCos\theta$
  - 3.1.3 F vs. s graph
  - *3.1.4 Work, energy velocity calculation
  - 3.1.5 Gravitational potential
  - 3.1.6 Spring potential energy
  - *3.1.7 Conservation: mechanical energy equation
  - *3.1.8 Hooke's law
  - 3.1.9 Conservation: spring mechanical energy

* Indicates Minimum Level Skills

● Indicates Essential Laboratory Activities

PHYSICS II B, ADVANCED

- 3.1.10 Free fall
- 3.1.11 Spring compression distance
- 3.1.12 Conservation: mechanical energy situations
- *3.1.13 Free fall velocity
- 3.1.14 Power against friction
- *3.1.15 Power to raise object

3.2 Impulse/Momentum
- 3.2.1 Impulse momentum derivation
- 3.2.2 Force/Time graph
- 3.2.3 $F = \frac{\Delta p}{\Delta t}$
- 3.2.4 Conservation: Newton's laws
- 3.2.5 Conservation: conditions
- 3.2.6 Linear collision
- *3.2.7 Non-linear collision
- 3.2.8 Final velocity ratio
- 3.2.9 Non-linear collision, loss of kinetic energy
- 03.2.10 Energy collision: two dimensions

3.3 Angular Momentum
- 3.3.1 Angular equivalents
- *3.3.2 Angular motion equation equivalents
- 3.3.3 Torque definition
- *3.3.4 Torque calculation
- 3.3.5 Angular acceleration
- 3.3.6 $I = mr^2$
- *3.3.7 Moment of inertia
- 3.3.8 Angular displacement
- 3.3.9 Angular momentum
- 3.3.10 Conservation: angular momentum
- 3.3.11 Angular kinetic energy

4.0 Gravity/Planetary Motion/ Oscillations

4.1 Gravity
- 4.1.1 Newton's law
- 4.1.2 Gravity/Distance graph
- *4.1.3 $F = G \frac{m_1 m_2}{s^2}$
- 4.1.4 Gravitational field: strength definition
- 4.1.5 Gravitational field: strength calculation

4.2 Planetary Motion
- 4.2.1 Kepler's laws
- 4.2.2 Periods/Orbits
- 4.2.3 Equation derivation: mass of earth
- 4.2.4 Derivation: period of satellite orbit

4.3 Oscillations
- *4.3.1 SHM definition
- *4.3.2 SHM graph
- 4.3.3 SHM velocity
- 4.3.4 SHM acceleration
- 4.3.5 Pendulum/Angle
- *4.3.6 Pendulum/Period
- 4.3.7 SHM period
- 4.3.8 SHM energy

5.0 Kinetic Theory/Thermodynamics

5.1 Temperature/Heat
- 5.1.1 Celsius/Kelvin scale
- 5.1.2 Calories/Joules
- 5.1.3 Melting/Boiling points
- 5.1.4 Heat: fusion, vaporization
- 5.1.5 Q calculation
- 5.1.6 Final temperature: mixed substances
- 5.1.7 Heat: mechanical equivalent

PHYSICS II B, ADVANCED

- 5.1.8 Heat: uniform slab of material
- 5.1.9 Black body radiation
- 5.1.10 Size/Shape

5.2 Ideal Gases
- 5.2.1 Kinetic theory assumptions
- 5.2.2 Mean translational kinetic energy
- 5.2.3 Temperature/Mean speed
- 5.2.4 Gas constants
- 5.2.5 Gas pressure
- 5.2.6 Fixed volume

5.3 Thermodynamics: First/Second Laws
- 5.3.1 First law definition
- 5.3.2 Second law definition
- 5.3.3 Isothermal: expansion, compression
- 5.3.4 Gas: constant volume, constant pressure calculation
- 5.3.5 Adiabatic: expansion, compression
- 5.3.6 pV diagrams
- 5.3.7 pV diagram: area, work
- 5.3.8 Free expansion
- 5.3.9 Internal energy changes

6.0 Electrostatics

6.1 Static charges
- 6.1.1 Coulomb's law
- 6.1.2 Force between two charges

6.2 Electric Fields
- *6.2.1 Definition
- 6.2.2 Direction
- *6.2.3 Force calculation
- 6.2.4 Flux lines
- 6.2.5 Diagram
- *6.2.6 Vector addition

6.3 Electric Potential
- *6.3.1 Definition
- *6.3.2 Electric work/Potential difference
- 6.3.3 Equal potential/Electric field
- 6.3.4 Conservation of energy/Speed charged particle
- 6.3.5 Potential difference/Uniform electric field
- 6.3.6 Potential function/Electric potential

6.4 Capacitors
- 6.4.1 Stored charge/Voltage
- 6.4.2 Electric field strength/Plate potential difference/Charge density
- 6.4.3 Parallel plate, electric field
- 6.4.4 Parallel plate, geometry
- 6.4.5 Dielectric

6.5 Conductors
- 6.5.1 Electric field
- 6.5.2 Equipotential
- 6.5.3 Conducting sphere

7.0 Electric Circuits

7.1 Electric Currents
- 7.1.1 Definition
- 7.1.2 Resistance
- *7.1.3 Ohm's law graph
- 7.1.4 Resistivity
- 7.1.5 Power
- 7.1.6 Heat

7.2 Circuits: Series/Parallel
- 7.2.1 Diagram
- 7.2.2 Series, voltage
- 7.2.3 Parallel, current

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*7.2.4 Resistance network: series, parallel, equivalent
7.2.5 Equivalent resistance
*7.2.6 Network : currents
7.2.7 Kirchkoff's rules
7.2.8 Power dissipation

7.3 Circuits/Resistors/Batteries/Capacitors
7.3.1 Equivalent capacitance
7.3.2 Parallel capacitors, stored charge
7.3.3 Series capacitors, voltage calculation
7.3.4 Steady state capacitor
7.3.5 Time constant
7.3.6 Capacitor discharge

8.0 Magnetism

8.1 Forces on Charges
*8.1.1 F = Bqv
8.1.2 No work case
8.1.3 Magnetic field, charged particle movement
8.1.4 Magnetic field, most general path
8.1.5 Crossed fields: electric, magnetic

8.2 Currents/Magnetic Fields
*8.2.1 F = BiI
8.2.2 Direction of magnetic force, current loop
*8.2.3 Magnetic field, long straight wire
8.2.4 Magnetic field, two long straight wires
8.2.5 Magnetic Attraction/Repulsion: two long straight wires

8.3 Electromagnetic Induction
8.3.1 Magnetic flux definition
8.3.2 Flux through a loop
8.3.3 Faraday's law
8.3.4 Lenz's law
8.3.5 Moving square loop, current induced
8.3.6 Changing field, induced current
8.3.7 Rotating loop, current induced
@8.3.8 Deflecting electrons

9.0 Waves/Optics

9.1 Mechanical Waves/Sound
9.1.1 Graphs/Standing waves
9.1.2 Superposition principle
*9.1.3 $v = \lambda f$
9.1.4 String: wave speed
9.1.5 Stretched string modes
*9.1.6 Pipes
9.1.7 Doppler shift, derivation
9.1.8 Doppler shift, observer motion
9.1.9 Doppler shift, source motion

9.2 Interference
9.2.1 Definition
*9.2.2 $n\lambda = a\sin\theta$
9.2.3 Constructive interference
9.2.4 Phase reversal
9.2.5 Reflection
9.2.6 Newton's rings

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*9.2.7 Intensity/Position graphs
9.2.8 Single slit, changing width
9.2.9 Single slit, minima
9.2.10 Double slit, changing width
9.2.11 Double slit, minima
9.2.12 Grating
9.2.13 Comparison: grating, double slit

9.3 Nature of Light
9.3.1 Electromagnetic spectrum
9.3.2 Polarization
9.3.3 Light pressure
9.3.4 Intensity, inverse square law
9.3.5 Intensity ratio, point source
●9.3.6 Spectroscope

9.4 Reflection/Refraction
9.4.1 Index of refraction
9.4.2 Ray diagram
*9.4.3 Snell's law
9.4.4 Internal reflection
●9.4.5 Refraction: measurement

9.5 Lenses/Mirrors
9.5.1 Ray tracing, mirror
9.5.2 Lens curvature
9.5.3 Ray tracing, lens
9.5.4 Lens maker equation
*9.5.5 Magnification
9.5.6 Lens applications

10.0 Modern Physics

10.1 Photons/Energy Level
10.1.1 Photon: energy, wave length
*10.1.2 Photon: energy, frequency
10.1.3 Photon momentum: energy, wavelength
10.1.4 Photon momentum: conservation
10.1.5 Photoemission rate
10.1.6 Photoelectric effect: proof of photon nature
10.1.7 Photoelectric effect, maximum kinetic energy
*10.1.8 Photoelectric effect, graphs
10.1.9 Photon energy, maximum kinetic energy
10.1.10 Hydrogen atom: ionization
10.1 11 Hydrogen atom: transition levels
10.1.12 Spectra: Emission/ Absorption
10.1.13 Transition: two step, single step
10.1.14 Hydrogen atom: ground-state energy
10.1.15 Hydrogen atom: energy levels
10.1.16 X-ray production
10.1.17 X-rays: shortest wavelength
10.1.18 Compton's scattering experiment: results
10.1.19 Compton's scattering experiment: photon wavelength
10.1.20 Compton wavelength
●10.1.21 Photoelectric stopping potentials

10.2 Wave Properties
*10.2.1 Momentum: particle wavelength
10.2.2 Davisson-Germer
10.2.3 Electron diffraction

COURSE OUTLINE

PHYSICS II B, ADVANCED

10.3 Nuclear Physics
- 10.3.1 Rutherford scattering
- 10.3.2 Half-life
- *10.3.3 Amount of substance, time
- 10.3.4 Half-life calculation
- 10.3.5 Symbols
- *10.3.6 Conservation
- 10.3.7 Decay equations
- 10.3.8 Decay processes
- 10.3.9 Neutrino

11.0 Special Relativity

11.1 Postulates
- 11.1.1 Definition
- 11.1.2 Absolutes
- 11.1.3 Description: Michelson-Morley
- 11.1.4 Significance: Michelson-Morley

11.2 Kinematic Effects
- 11.2.1 Time
- 11.2.2 Length
- 11.2.3 Mass
- 11.2.4 Speeds

11.3 Mass/Energy
- 11.3.1 Graphs: kinetic energy, speed
- 11.3.2 Kinetic energy calculation
- 11.3.3 Energy conversion

PERFORMANCE OBJECTIVES
PHYSICS II B, ADVANCED

1.0 Kinematics

1.1 To demonstrate knowledge of motion in one dimension, students will:

*(1) identify the graph of velocity vs. time when given a plot of position vs. time;

(2) sketch a graph of position vs. time when given a graph of velocity vs. time;

(3) sketch a graph of acceleration vs. time when given a graph of velocity vs. time;

(4) sketch a graph of velocity vs. time and position vs. time of a ball thrown vertically upward from the time it is thrown until the time that it is returned to earth;

*(5) solve a problem where acceleration is constant using the equations $v = v_o + at$, or $s = s_o + v_o t + \frac{1}{2}at^2$, or $v^2 = v_o^2 + 2as$; and

●(6) determine the equation, including the constant of proportionality, that describes an event when given data taken from observations of an event involving three interrelated, varying quantities.

1.2 To demonstrate knowledge of vectors, students will:

(1) add vectors in order to find the net displacement of a particle which undergoes successive straight line displacements;

(2) subtract position vectors in order to find the change in position of a particle;

(3) subtract velocity vectors in order to find the change in velocity of a particle;

(4) calculate the magnitude of the components resolved on two specified mutually perpendicular axes when given the magnitude and direction of a vector; and

(5) use specified values of magnitude and direction to solve the vector equation, $s = vot + \frac{1}{2}at^2$.

* Indicates Minimum Level Skills
● Indicates Essential Laboratory Activities

1.3 To demonstrate knowledge of projectile motion, students will:

(1) state the range equation for a projectile as

$R = \frac{2V_o^2}{g} \text{CosθSinθ}$;

*(2) solve for the range of a projectile fired at an angle of θ and an initial velocity v_o; and

(3) derive the range equation from the motion equations and the horizontal and vertical components of the initial projectile velocity.

1.4 To demonstrate knowledge of circular motion, students will:

(1) derive the equations for centripetal acceleration, $a_c = \frac{4\pi^2 r}{T^2}$ and $a_c = \frac{v^2}{r}$, using the period and magnitudes of the vectors describing the instantaneous position and velocity of a point in a state of uniform circular motion;

*(2) use the centripetal acceleration equations, $a_c = \frac{4\pi^2 r}{T^2}$ and $a_c = \frac{v^2}{r}$, to calculate the centripetal acceleration of a point in a state of uniform circular motion;

(3) define uniform circular motion as a point moving in a circle with a constant speed and radius of orbit;

(4) state that the direction of centripetal acceleration is always toward the center of orbit and that the direction of the orbital velocity is always at right angles to the radius of orbit; and

(5) use the equation $v = \frac{2\pi r}{T}$ to calculate the orbital speed of a point in a state of uniform circular motion.

2.0 Newton's Laws of Motion

2.1 To demonstrate knowledge of the dynamics of a single body, students will:

(1) calculate the value of an unknown force where a situation exists such that a bar of mass M is in a state of static equilibrium under the influence of several forces;

*(2) calculate the value of an unknown lever arm where a situation exists, such that a bar of negligible mass is in a state of static equilibrium under the influence of several forces, from a diagram showing appropriate values;

(3) solve a problem that requires the simultaneous solution of the equations describing the equilibrium of moments and the equilibrium of forces;

*(4) identify the definition of the coefficient of static friction as the maximum force of friction divided by the normal force;

(5) define the coefficient of kinetic friction as the force of friction divided by the normal force;

(6) state that the force of friction is the product of the normal force and the coefficient of friction;

(7) calculate the force of kinetic friction between the surface of a block moving in a state of equilibrium of forces and a horizontal surface;

(8) calculate the minimum coefficient of static friction necessary to hold a block at rest on a plane inclined at some angle θ;

(9) construct a well-labeled diagram showing all real forces which act on a body;

(10) derive the vector equation which results from applying Newton's second law to a body under the influence of several coplanar, nonlinear forces and take components of this equation along appropriate axes;

*(11) calculate the rate of acceleration of a block being pulled along a horizontal surface by a horizontal force where the coefficient of kinetic friction is μ_k;

(12) calculate the apparent weight of an object in an elevator that is experiencing a constant vertical acceleration;

*(13) calculate the distance traveled by an object in a specified time period given that a constant force is applied on the object;

(14) solve a problem involving an object accelerating on an inclined plane under the influence of a force other than that of gravity;

(15) show that the equations $a = \frac{4\pi^2 r}{T^2}$ and $a = \frac{v^2}{r}$ can be substituted into Newton's Second Law to form equations for the calculation of centripetal force;

(16) calculate the radius of orbit of an object which is undergoing uniform circular motion when given the mass and period of the object and the centripetal force;

(17) calculate the friction force necessary to hold a car rounding a banked curve;

(18) calculate the tension in a string that is causing an object to rotate in a vertical circle; and

(19) measure the inertial mass of various objects using an inertial balance.

2.2 To demonstrate knowledge of systems of two or more bodies, students will:

(1) identify the body on which the reaction to a given force acts;

(2) calculate the tension in a string for a two-body system on a horizontal surface which is accelerating in the direction of the leading body, given that the two bodies are connected by a light string and an outside force is applied to the leading body; and

(3) calculate the rate of acceleration of two objects given that the objects are connected by a light string passing over a frictionless pully of negligible mass.

3.0 Conservation Laws in Classical Mechanics

3.1 To demonstrate comprehension of energy, students will:

(1) derive, starting with Newton's Second Law, the equation which states that work equals change in kinetic energy;

*(2) calculate the work done on an object by a force acting at an angle, using the equation $W = F\cos\theta$;

(3) state that the area under a graph of force vs. distance represents work;

*(4) calculate the final velocity of an object, using the work equals change in kinetic energy equation, when given the work done on an object and the initial velocity and mass of the object;

(5) state that the equation for the change in gravitational potential energy near the surface of the earth is $PE = mgh_2 - mgh_1$;

(6) state that the equation for the change in the potential energy of an ideal spring is $PE = \frac{1}{2}kx_2^2 - \frac{1}{2}kx_1^2$;

*(7) identify the conservation of mechanical energy equation $\frac{1}{2}mv_2^2 + mgh_2 = \frac{1}{2}mv_1^2 + mgh_1$ when gravity is the only force doing work near the surface of the earth;

*(8) identify Hooke's law as $F = -kx$ for the case where a force is applied to a stretcher spring;

(9) state that, when an ideal spring is the only force doing work, the conservation of mechanical energy equation is:

$$\frac{1}{2}mv_2^2 + \frac{1}{2}kx_2^2 = \frac{1}{2}mv_1^2 + \frac{1}{2}kx_1^2;$$

(10) using the conservation of energy principle, calculate the final velocity of an object falling a specified distance when the object is thrown vertically downward from the top of a building;

(11) calculate the maximum compression distance of an ideal spring with force constant k when given the speed of an object approaching the spring on a horizontal frictionless surface;

(12) state whether mechanical energy is or is not conserved when given different situations;

*(13) calculate the final velocity of an object falling a specified distance from rest given the mass of the object and the work done by air friction;

(14) calculate the power required to keep an object moving at a specified constant speed on a horizontal surface against the force of friction; and

*(15) calculate the power necessary to raise an object a specified distance when given the mass of the object and the time required to raise it.

3.2 To demonstrate knowledge of impulse and momentum, students will:

(1) derive the relationship between impulse and change in momentum starting with Newton's Second Law;

(2) state that the area under a graph of force vs. time represents impulse;

(3) state that $\vec{F} = \frac{\vec{\Delta P}}{\Delta t}$ is an alternate method of writing Newton's Second Law;

(4) show that Newton's Second and Third Laws can be combined to predict the conservation of momentum;

(5) state that under all conditions momentum is conserved as a vector quantity;

(6) calculate the final velocity of two objects which stick together in an in-line collision when given the mass and initial velocity of each;

*(7) calculate the resultant velocity of two objects which stick together after collision, given that they were originally traveling in specified, non-linear directions on a frictionless surface;

(8) calculate the ratio of the final velocities of two masses that are pushed apart from rest by a light, ideal spring;

(9) calculate the loss of kinetic energy that results from a collision when given that two objects traveling in specified, non-linear directions collide on a frictionless surface; and

●(10) determine the extent to which momentum is conserved as a vector quantity by measuring collisions in two dimensions.

3.3 To demonstrate knowledge of angular momentum, students will:

(1) identify the angular equivalents for the linear quantities position, displacement, speed, acceleration, mass, force, and momentum;

(2) identify the angular equivalents for the linear equations $v = v_o + at$, $s = v_o t + \frac{1}{2}at^2$, $v^2 = v_o^2 + 2as$, $F = ma$, or $P = mv$;

*(4) calculate the resultant torque (T) when given a diagram showing the values of the moment arm (r) of a force, the force $(F)_1$ and the angle between the two (θ);

(5) identify torque as a quantity that causes the angular acceleration of objects;

(6) state that the equation for the moment of inertia of a point mass is $I=mr^2$;

*(7) select the object that has the largest or smallest moment of inertia when given a description of the shape, mass, and size of various objects;

(8) calculate the angular displacement over a specified time period for an object starting rotation from rest and accelerating at a constant angular rate, given the torque on the object and the moment of inertia of that object;

(9) calculate the final angular momentum of a rotating object when given the applied torque, the duration of the torque, and the moment of inertia of the object;

(10) calculate the final angular velocity of two discs assuming that they rotate at the same rate after interacting when given that a solid rotating disc has a common axis with a stationary disc on a frictionless surface, and that the rotating disc is dropped on the stationary disc; and

(11) explain the following situation: "Two identical discs, each resting on its rim, are released from the top of inclined planes that have equal lengths and equal angles of inclination. However, the nature of the surfaces of the two planes differ, and the result of this difference is that one disc slides on its rim while the other rolls. Upon arriving at the bottom of their respective inclined planes, the sliding disc has a greater speed than the rolling disc."

4.0 Gravity, Planetary Motion, and Oscillations

4.1 To demonstrate knowledge of gravity, students will:

(1) state Newton's law of Gravity;

(2) select the correct graph concerning the earth's gravity vs. distance from the surface of the earth when given a collection of graphs;

*(3) calculate the force of gravity between two objects given their masses and separation distance of the two objects;

(4) state that gravitational field strength is defined as the force of gravity per unit mass; and

(5) calculate the gravitational field strength of the earth using a specified distance from the surface of the earth.

4.2 To demonstrate knowledge of planetary motion, students will:

(1) state Kepler's three laws of planetary motion;

(2) calculate the ratio of the period of orbit of two satellites when given the ratio of their radii of orbit;

(3) derive an equation from Newton's Second Law and Newton's law of gravity that can be used to calculate the mass of the earth; and

(4) calculate the period of orbit of a satellite when given its radius of orbit, the mass of the earth, and the universal gravitational constant.

4.3 To demonstrate knowledge of oscillations, students will:

*(1) state that simple harmonic motion of an object results from the application of a net force such that the force is always directly proportional to the displacement in magnitude and opposite the displacement in direction;

*(2) determine the amplitude or period, and frequency of a simple harmonic oscillator from a graph of displacement vs. time;

(3) identify the points in simple harmonic motion where the velocity is zero or achieves its maximum positive or negative value;

(4) discuss qualitatively the relationship between acceleration and displacement in simple harmonic motion, including the location of points in the motion where the acceleration is zero or achieves its greatest positive or negative value;

(5) state that the accuracy of the equation for the period of a simple pendulum decreases as the angle of swing increases,

*(6) calculate the period of a simple pendulum;

(7) calculate the period of oscillation of an object forced to oscillate by a spring given the mass of the object, and the force constant of the spring; and

(8) discuss the relationship between the kinetic and potential energy of a simple harmonic oscillator, including an identification of the points in the motion where this energy is all potential or all kinetic.

5.0 Kinetic Theory and Thermodynamics

5.1 To demonstrate knowledge of temperature and heat, students will:

(1) convert temperatures from Celsius to the Kelvin scale including the freezing and boiling points of water;

(2) convert heat energy from calories to joules;

(3) identify the melting and boiling points of a substance when given a graph showing quantity of heat added to the substance as a function of its temperature;

(4) identify the heats of fusion and vaporization for a substance and the specific heat for each phase when given a graph showing quantity of heat added to the substance as a function of its temperature;

(5) calculate the amount of heat required to cause a given change in temperature when given the mass, specific heat, and change in temperature of the substance;

(6) calculate the final temperature achieved when substances at different temperatures are mixed and allowed to come to thermal equilibrium;

(7) calculate, using the concept of the mechanical equivalent of heat, the increase in temperature of a given amount of liquid when a specified amount of mechanical work is done on that liquid, assuming no heat loss;

(8) calculate the amount of heat flowing through a uniform slab of material using the equation $Q = KAT\left(\frac{t_2-t_1}{d}\right)$

(9) sketch graphs showing the power radiated by a black body as a function of frequency at different temperatures; and

(10) identify what happens to the size and shape of a body when it experiences an increase in temperature.

5.2 To demonstrate knowledge of kinetic theory and thermodynamics of ideal gases, students will:

(1) state the assumptions of the kinetic theory model of an ideal gas;

(2) identify the relationship between the temperature and the mean translational kinetic energy of an ideal gas;

(3) predict the relationships among the temperature, the mean molecular speed, and the molecular mass of an ideal gas;

(4) differentiate among Avogadro's number, Boltzmann's constant, and the gas constant R, comparing the energy of a mole of a monatimic ideal gas to its temperature;

(5) discuss qualitatively how the ideal gas model explains the pressure of a gas in terms of collisions with the container walls; and

(6) state that an ideal gas model predicts that pressure must be proportional to temperature for a fixed volume.

5.3 To demonstrate knowledge of the first and second laws of thermodynamics, students will:

(1) state the first law of thermodynamics (all the heat energy added to a closed system can be accounted for as mechanical work, an increase in internal energy, or both);

(2) state the second law of thermodynamics (the entropy of the universe never decreases; during any process, the entropy either remains constant or else increases);

(3) compare the pressure and volume of a gas during an isothermal expansion or compression;

(4) calculate the heat absorbed or given off by a gas in a constant-volume or constant-pressure process;

(5) state what is meant by an adiabatic expansion or compression of a gas;

(6) identify on a pV diagram the curves which represent isothermal expansion and compression, adiabatic expansion and compression, constant-volume expansion and compression, and constant-pressure expansion and compression;

(7) identify the work performed in a cyclic process as the area enclosed by a curve on a pV diagram;

(8) state the changes that occur if a gas expands freely to fill a larger container; and

(9) discuss how the heat absorbed by a gas, the work performed by the gas, and the internal energy change of the gas are related to isothermal, adiabatic, constant-volume, and constant-pressure processes.

6.0 Electrostatics

6.1 To demonstrate knowledge of the behavior of static charges, students will:

(1) state Coulomb's law; and

(2) calculate the force between two spherical charges when given the value of the two charges and the distance between them;

6.2 To demonstrate knowledge of electric fields, students will:

*(1) state the definition of an electric field (the electric force per unit charge);

(2) apply the statement: "The direction of an electric field is the same as the direction of the force the field will apply to a positive charge," to a situation where a positive or negative electric charge is moving through an electric field;

*(3) calculate the magnitude and direction of the force on a positive or negative charge placed in a specific electric field;

(4) calculate the force which exists between two specified point charges;

(5) diagram the electric fields of both positive and negative charges for a single point charge, two like point charges in proximity, two unlike point charges in proximity, a sheet of charge, and two oppositely charged parallel sheets; and

*(6) use vector addition to calculate the electric field strength at some point on a line that bisects two point charges, when given the magnitude and the separation distance of the charges.

6.3 To demonstrate knowledge of electric potential, students will:

*(1) identify the definition of the electric potential at a point P as the work per unit charge that is required to bring a test charge from infinity to point P;

*(2) calculate the electric work done on a specified amount of positive or negative charge that moves through a given potential difference;

(3) predict the direction and approximate magnitude of the electric field at various positions given a sketch of equipotentials for a charge configuration;

(4) apply conservation of energy to deduce the speed of a charged particle which has been accelerated through a specified potential difference;

(5) calculate the potential difference between two points in an uniform electric field. stating which is at the higher potential; and

(6) calculate, using the potential function for a point charge, the electric potential in the vicinity of one or more point charges.

6.4 To demonstrate knowledge of capacitors, students will:

(1) discuss the relationship of stored charge and voltage for a capacitor by using the definition of capacitance;

(2) state the relationships among the strength of the electric field of a parallel-plate capacitor, the potential difference between the plates, and the density of the charge on the plates;

(3) differentiate between the electric field inside a parallel-plate capacitor and that of other charge configurations;

(4) discuss the relationship between the capacitance and the geometry of a parallel-plate capacitor; and

(5) discuss the insertion of a dielectric between the plates of a charged parallel-plate capacitor as it affects capacitance, field strength, and voltage between the plates.

6.5 To demonstrate knowledge of electrostatics with conductors, students will:

(1) explain the mechanism responsible for the absence of an electric field inside a conductor;

(2) apply the principle of equipotentiality of conductors to predict the results of joining conductors with wires; and

(3) identify a graph of the electric field or potential inside and outside a charged conducting sphere.

7.0 Electric Circuits

7.1 To demonstrate knowledge of electric current, resistance, and power, students will:

(1) compare the magnitude and direction of the current in a wire or ionized medium to the rate of flow of positive and negative charge including a definition of electric current in the comparison;

(2) identify the definition of electrical resistance;

*(3) select from several graphs of voltage vs. current the one that describes Ohm's law;

(4) state the relationship among resistance of a resistor, its length, and its cross-sectional area;

(5) state that the equations for electric power in an ohmic resistor are $P = VI$ and $P = I^2R$; and

(6) calculate the rate at which heat is produced when current passes through an ohmic resistor.

7.2 To demonstrate knowledge of direct-current circuits, students will:

(1) identify on a circuit diagram resistors which are in series or parallel;

(2) calculate the ratio of the voltages across resistors connected in series;

(3) calculate the ratio of the currents through resistors connected in parallel;

*(4) calculate the equivalent resistance of two or more resistors connected in series or in parallel;

(5) calculate the equivalent resistance of a network of resistors which can be broken down into series and parallel combinations;

*(6) calculate the electric currents that exist in each resistor of a network when given a series-parallel resistance network of known resistances attached to a specified voltage source;

(7) determine any unknown current, voltage, or resistance using Kirckhoff's rules when given a series-parallel resistance network containing at least two sources of voltage, each at different points; and

(8) calculate the power dissipation for a resistor in a network when given a series-parallel resistance network containing a source of known voltage.

7.3 To demonstrate knowledge of circuits containing batteries, resistors, and capacitors, students will:

(1) calculate the equivalent capacitance of a series or parallel combination of capacitors;

(2) discuss how stored charge is divided between two capacitors connected in parallel;

(3) calculate the ratio of the voltages for two capacitors when given a circuit containing two capacitors and a battery in series;

(4) calculate the voltage or stored charge, under steady state conditions, for a capacitor connected to a circuit consisting of a battery and resistors;

(5) calculate the time constant for a circuit when given a circuit containing a resistor, capacitor, and battery in series; and

(6) identify the graph that represents the discharging of a charged capacitor through a resistor when given several graphs of current vs. time.

8.0 Magnetism

8.1 To demonstrate knowledge of forces on charges, students will:

*(1) calculate the magnitude and direction of the force on a charged particle when given the amount of charge, the velocity of the particle, and the strength of the magnetic field through which the particle is moving;

(2) explain why a magnetic force can do no work on a charged particle that is moving without restraint;

(3) derive an equation, starting with Newton's Second Law and the magnetic force law, that will allow for the calculation of the radius of the circular path of a charged particle that moves perpendicular to a uniform magnetic field;

(4) predict the most general path possible for a charged particle moving in a uniform magnetic field; and

(5) discuss quantitatively the conditions under which particles will move with constant velocity through crossed electric and magnetic fields.

8.2 To demonstrate knowledge of currents and magnetic fields students will:

*(1) calculate the magnetic force on a current-carrying wire when given the length of wire, magnitude of the current, and strength of the magnetic field containing the wire;

(2) predict the direction of magnetic force on a current-carrying loop of wire in a magnetic field;

*(3) calculate the magnitude and direction of the magnetic field at a specified distance from a very long straight wire when given the magnitude of the current passing through the wire;

(4) predict, using a superposition, the magnitude and direction of the magnetic field produced by two long, straight, parallel wires; and

(5) calculate the magnetic force of attraction or repulsion between two long current-carrying wires.

8.3 To demonstrate knowledge of electromagnetic induction, students will:

(1) state the definition of magnetic flux;

(2) calculate the flux of a uniform magnetic field through a loop of arbitrary orientation;

(3) state Faraday's law as $E = \frac{\Delta\phi}{\Delta t}$, where E is emf and $\frac{\Delta\phi}{\Delta t}$ is the rate of change of magnetic flux;

(4) state Lenz's law (an induced emf tends to set up a current whose action opposes the change that caused it);

(5) calculate the magnitude and direction of the current induced in a square loop of specific dimensions that is being pulled with a given force and at a specific constant velocity through a known uniform magnetic field;

(6) calculate the magnitude and direction of the current induced in a loop of wire placed in a spatially uniform magnetic field whose magnitude is changing at a constant rate;

(7) calculate the magnitude and direction of the current induced in a loop of wire which rotates at a constant rate about an axis perpendicular to a uniform magnetic field; and

●(8) observe the effects of various electric fields on the electron beam in a cathode ray tube.

9.0 Waves and Optics

9.1 To demonstrate understanding of mechanical waves and sound, students will:

(1) sketch graphs which represent traveling or standing waves, indicating the amplitude and wavelength of the waves on the graphs;

(2) apply the principle of superposition to traveling waves moving in opposite directions, discussing how a standing wave may be formed.

*(3) calculate the wavelength when given the velocity and frequency of a wave;

(4) calculate the speed of a transverse wave in a string given the tension and the mass per unit length of the string;

(5) sketch possible standing wave modes for a stretched string which is fixed at both ends, calculating the wavelength and frequency of such standing waves;

*(6) calculate the wavelength or frequency of a standing sound wave in a pipe which has either open or closed ends;

(7) discuss the mechanism which gives rise to a frequency shift in both the moving-source and moving-observer case, deriving an expression for the frequency heard by the observer;

(8) state the equations for the Doppler effect of sound waves where the source is in motion or where the observer is in motion; and

(9) calculate the frequency of an emitted sound of specific velocity as heard by a stationary observer with the source approaching the observer.

9.2 To demonstrate knowledge of the interference phenomena, students will:

(1) discuss the way that waves, emitted by two coherent sources which oscillate in phase, interfere constructively or destructively when reaching an observation point;

*(2) solve problems for double slit interference patterns using the antinode equation, $n\lambda = a\sin\theta$;

(3) compare the amplitude and intensity produced by two or more sources which interfere constructively to the amplitude and intensity produced by a single source;

(4) discuss the conditions under which a phase reversal occurs if light is reflected from the interface between two media of different indices of refraction;

(5) state whether rays of monochromatic light which are reflected from two surfaces of different indices of refraction will interfere constructively or destructively;

(6) discuss the formation of Newton's rings and similar phenomena, describing how glass may be coated to minimize reflection of visible light;

*(7) differentiate among the interference patterns formed by single slits, double slits, and multiple slits using a graph of light intensity vs. position;

(8) compare an intensity pattern sketch of monochromatic light passing through a single slit and falling on a distant screen with intensity pattern sketches for the same case when the slit width or wavelength is changed;

(9) calculate, for a single-slit pattern of monochromatic light, the positions on a distant screen where the light intensity is zero;

(10) compare an intensity pattern sketch of monochromatic light passing through a double slit and falling on a distant screen with intensity pattern sketches for the same case when the slit width or slit separation distance is changed;

(11) calculate, for a two-slit interference pattern, the angles at which intensity maxima or minima occur;

(12) sketch the interference pattern of monochromatic light formed by a grating of many equally spaced narrow slits; and

(13) discuss qualitatively why a multiple-slit grating is better than a two-slit grating for making accurate determinations of the wavelength of light.

9.3 To demonstrate knowledge of the nature of light, students will:

(1) arrange the following in order of increasing wavelength: ultraviolet light, infrared light, radio waves, x-rays, and gamma rays;

(2) discuss qualitatively the way in which the transverse nature of light waves allows light to exhibit polarization;

(3) apply the equation $P = S/c$, where S is the intensity of the radiation, in units of watts per square meter, P is the pressure of the light, and c is the speed of light;

(4) calculate, using the inverse square law, the intensity of light from a specified source at a given distance;

(5) calculate the intensity of light at a specific distance from a point source when given the intensity of light at a different distance from the point source; and

*(6) observe the spectrum of hydrogen using a spectroscope.

9.4 To demonstrate knowledge of reflection and refraction of light, students will:

(1) discuss the effect of the index of refraction on the speed and wavelength of light as it passes from one medium into another;

(2) sketch ray diagrams describing the reflection and refraction of light as it strikes an interface between two media of different indices of refraction;

*(3) calculate the angle of refraction using Snell's law;

(4) calculate the angle for total internal reflection in a specific medium when given Snell's law; and

*(5) measure refraction in various liquids.

9.5 To demonstrate knowledge of lenses and mirrors, students will:

(1) locate qualitatively, for a plane or spherical mirror by ray tracing, the image of a real object determining whether the image is real or virtual, upright or inverted;

(2) predict whether the focal length of a converging or diverging lens is increased or decreased as a result of a change in the curvature of its surfaces or in the index of refraction of the material of which the lens is made or the medium in which the lens is immersed;

(3) by ray tracing, locate the image of a real object located inside or outside the focal point of a lens, stating whether the resulting image is upright or inverted, real or virtual;

(4) using the lens-makers equation, compute the object distance, image distance, and focal length for a lens;

*(5) compare image size to object size by calculation when given the image distance and the object distance; and

(6) identify a diagram showing how a lens functions in a camera, a slide projector, or a magnifying glass.

10.0 Modern Physics

10.1 To demonstrate knowledge of photons and energy levels, students will:

(1) compare the energy of a photon in joules or electron volts to its wavelength in nanometers;

*(2) calculate the energy of a photon given its frequency in hertz;

(3) compare the linear momentum of a photon to its energy or wavelength;

(4) discuss the application of linear momentum conservation to simple processes involving the emission or absorption of photons;

(5) calculate the number of photons per second emitted by a monochromatic source of specific wavelength and power;

(6) discuss a typical photoelectric effect experiment stating experimental observations which provide evidence for the photon nature of light;

(7) discuss qualitatively how the number of photoelectrons and their maximum kinetic energy depend on the wavelength and intensity of the light striking the surface stating this dependence in terms of a photon model of light;

*(8) from a group of graphs of stopping potential vs. frequency, select the one that correctly describes the emission of photoelectrons;

(9) calculate the maximum kinetic energy of photoelectrons for a different photon energy or wavelength when given the maximum kinetic energy of photoelectrons ejected;

(10) calculate the energy in electron volts necessary to ionize a hydrogen atom from ground state using the equation $hf = 13.3 \left(\frac{1}{n^2} - \frac{1}{m^2} \right)$;

(11) calculate the wavelength of the photon emitted or absorbed in a transition between specified energy levels in the hydrogen atom;

(12) discuss qualitatively the origin of emission or absorption spectra of gases;

(13) calculate the wavelength or energy for a single-step transition between the same levels as a two-step transition when given the wavelengths or energies of photons emitted or absorbed in the two-step transition;

(14) state an expression for the energy levels of hydrogen in terms of ground-state energy;

(15) sketch a diagram to depict the various energy levels in the hydrogen atom discussing how this diagram accounts for the various "series" in the hydrogen spectrum;

(16) discuss the process by which x-rays are produced including a sketch of the apparatus which produces x-rays in the discussion;

(17) calculate the shortest wavelength of x-rays which may be produced by electrons accelerated through a specified voltage;

(18) describe Compton's scattering experiment stating what results were observed and by what sort of analysis these results may be explained;

(19) discuss qualitatively the increase of photon wavelength which is observed in Compton's scattering experiment;

(20) discuss the significance of the Compton wavelength; and

•(21) observe stopping potentials for a photoelectric surface.

10.2 To demonstrate knowledge of wave properties of matter, students will:

*(1) calculate the wavelength of a particle as a function of its momentum using the equation $\lambda = \frac{h}{mv}$;

(2) discuss the Davisson-Germer experiment explaining how it provides evidence for the wave nature of electrons; and

(3) use the wave properties of electrons to determine the form of the diffraction pattern which arises when electrons pass through a single or double slit.

10.3 To demonstrate knowledge of nuclear physics, students will:

(1) discuss the Rutherford scattering experiment and state how it provides evidence for the existence of the atomic nucleus;

(2) state that half-life is independent of the number of nuclei present or external conditions;

*(3) calculate the amount of radioactive substance remaining after a specified number of half-times have elapsed, given a graph of the amount of a radioactive substance.

(4) calculate what fraction of the nuclei has decayed after a given time has elapsed;

(5) state the symbols for the mass number and charge of the nuclei;

*(6) complete nuclear reactions using conservation of mass number and charge;

(7) write alpha, beta, and gamma decay reactions;

(8) calculate the mass number and charge of a nucleus after it has undergone a specified decay process; and

(9) discuss the role of the neutrino in beta decay in such a way that an explanation can be offered as to why its existence had to be postulated.

11.0 Special Relativity

11.1 To demonstrate knowledge of the postulates of special relativity, students will:

(1) state the two postulates upon which Einstein based his special theory of relativity;

(2) discuss the absolute nature of the speed of light;

(3) describe the Michelson-Morley experiment; and

(4) discuss the significance of the Michelson-Morley experiment.

11.2 To demonstrate knowledge of the kinematic effects predicted by special relativity, students will:

(1) compare the lifetime of a fast-moving elementary particle or other "clock", as timed by two stationary clocks, to the lifetime of such a particle in its rest frame;

(2) solve a problem using the length contraction equation,

$$L = L_0 \sqrt{1 - \frac{v^2}{c^2}};$$

(3) calculate the relativistic mass of an object at a specified speed when given the rest mass; and

(4) calculate the apparent speed of an object from a frame of reference where another object is considered at rest when given that the two objects are moving at high speeds in opposite directions.

11.3 To demonstrate knowledge of the relationship between mass and energy, students will:

(1) select from a group of graphs of the kinetic energy of a particle vs. speed, the one that correctly represents a range of speeds from rest to the speed of light;

(2) calculate kinetic energy of a moving particle in terms of its rest mass and speed; and

(3) discuss one physical process in which kinetic energy is converted to rest energy and one in which rest energy is converted to kinetic energy.

KEY TO RECOMMENDED INSTRUCTIONAL MATERIALS *

Performance Objective		Instructional Implications		Resources	
Number	Topic	Teaching Time	Tested on	County Adopted	Supplementary
1.0	Kinematics	2 weeks	MLST	Franklin Miller, Jr., College Physics (New York: Harcourt Brace Jovanovich, Inc., 1982). pp. 22-54.	
2.0	Newton's Laws	4 weeks	MLST	Miller, pp. 55-72, 156-60.	
3.0	Conservation Laws	3 weeks	MLST	Miller, pp. 84-89, 108-13, 125-47, 151-55, 161-72.	
4.0	Gravity/ Oscillations	2 weeks	MLST	Miller, pp. 177-215.	
5.0	Kinetic Theory	3 weeks		Miller, pp. 310-89.	
6.0	Electro-statics	3 weeks	MLST	Miller, pp. 390-419.	
7.0	Electric Circuits	2 weeks	MLST	Miller, pp. 454-81.	
8.0	Magnetism	2 weeks	MLST	Miller, pp. 482-512.	

* This is a key to the 1982 edition of College Physics. The 1977 edition is keyed on pages PIIB-33 and PIIB-34.

KEY TO RECOMMENDED INSTRUCTIONAL MATERIALS

Performance Objective		Instructional Implications		Resources	
Number	Topic	Teaching Time	Tested on	County Adopted	Supplementary
9.0	Waves Optics	6 weeks	MLST	Miller, pp. 219-64, 570-621.	
10.0	Modern Physics	5 weeks	MLST	Miller, pp. 686-819.	
11.0	Special Relativity	2 weeks		Miller, pp. 663-667, 676.	

PIIP-32

KEY TO RECOMMENDED INSTRUCTIONAL MATERIALS *

Performance Objective		Instructional Implications		Resources	
Number	Topic	Teaching Time	Tested on	County Adopted	Supplementary
1.0	Kinematics	2 weeks	MLST	Franklin Miller, Jr., College Physics (New York: Harcourt Brace Jovanovich, Inc., 1977), pp. 26-55, 174-76.	
2.0	Newton's Laws	4 weeks	MLST	Miller, pp. 57-67, 82-108.	
3.0	Conservation Laws	3 weeks	MLST	Miller, pp. 114-39, 172-74, 177-85, 208-13.	
4.0	Gravity and Oscillations	2 weeks	MLST	Miller, pp. 68-74, 186-91, 208-17.	
5.0	Kinetic Theory	3 weeks		Miller, pp. 308-80.	
6.0	Electro-statics	3 weeks	MLST	Miller, pp. 381-89, 400-09.	
7.0	Electric Circuits	2 weeks	MLST	Miller, pp. 410-21, 425-37, 443-51.	
8.0	Magnetism	2 weeks	MLST	Miller, pp. 471-98.	

* This is a key to the 1977 edition of College Physics.

KEY TO RECOMMENDED INSTRUCTIONAL MATERIALS

Performance Objective		Instructional Implications		Resources	
Number	Topic	Teaching Time	Tested on	County Adopted	Supplementary
9.0	Waves and Optics	6 weeks	MLST	Miller, pp. 227-67, 556 -639.	
10.0	Modern Physics	5 weeks	MLST	Miller, pp. 646-767.	
11.0	Special Relativity	2 weeks		Miller, pp. 153-163.	

PIIB-34

KEY TO LABORATORY RESOURCES

Uri Haber-Schaim, et al, Laboratory Guide PSSC Physics (Lexington, Massachusetts: D. C. Heath and Company, 1981).

Objective	Skill	County Adopted Text Pages	Other Resources
	Students will:		
1.1.6	determine the equation, including the constant of proportionality, that describes an event when given data taken from observations of an event involving three interrelated, varying, quantities.	100-02	
2.1.9	observe the inertial mass of various objects using an inertial balance.	7-9	
3.2.10	determine the extent to which momentum is conserved as a vector quantity by observing collisions in two dimensions.	19-22	
8.3.8	observe the effects of various electric fields on the electron beam in a cathode ray.	37-40	
9.3.6	observe the spectrum of hydrogen using a spectroscope.	93-95	

PIIB-35

INTRODUCTION
SCIENCE RESEARCH, ADVANCED

State Accreditator Number. .	1329
Course Code Number	2511
F.T.E. Category.	1.10
Instructional Level.	Advanced

Report Card Abbreviation . .	Sci Research Adv
Length of Course	Year
Credit	1 Science credit
Grade Level.	11, 12

Prerequisites

Departmental approval (see "Notes to Teachers, " below); current enrollment in Biology II, Advanced; Chemistry II, Advanced; Physics II, Advanced; or Marine Biology II, Advanced

Textbook(s)

None

Performance Objective

The senior high science student will complete an independent research project, presenting the results both orally and in writing to the satisfaction of the teacher.

Notes to Teachers

The Science Research course is designed to provide opportunity for interested students to participate in extensive, directed, individual research. Although there is much flexibility for both teacher and student, it is necessary that certain minimum standards be followed to ensure that advanced credit is warranted.

Prerequisites for acceptance into the course are:

1. Current enrollment in Biology II, Advanced; Chemistry II, Advanced; Marine Biology II, Advanced; or Physics II, Advanced.

2. Teacher recommendation

3. Submission of a one-page project proposal by the student and subsequent approval by the teacher

4. Availability of laboratory equipment and supplies necessary for planned laboratory research

5. Verification of student knowledge of lab safety procedures based upon an interview by a previous teacher

Minimum Project Requirements

1. A minimum of 75 hours spent in the field or laboratory

2. Preparation of a paper whose format conforms to accepted standards for publication of research in scientific journals, e.g. Science. The paper will include:

   (1) introduction with statement of problem and hypothesis,

   (2) background research,

   (3) description of experimental design, including identification of variables and controls,

   (4) data collected, presented in tables, graphs, and diagrams, and

   (5) conclusions.

3. Weekly contact between teacher and student regarding progress of the project; students may not contact local agency personnel without teacher assistance and approval.

4. Results of student project must be presented to an advanced class, entered in the Junior Academy of Science program, or entered in the science fair. The student should prepare all visuals for the presentation.

Suggested Guidelines for Background Research

The topic for research may be assigned by the teacher or selected by the student. It is recommended that topics be of such a nature that current information (e.g., periodicals) is available. The text of the completed paper should be the equivalent of 10-15 typed, double-spaced pages. Prior to the final paper, preliminary products will be reviewed by the teacher. A guide for each product follows:

1. Working Bibliography

The working bibliography is a listing, in proper bibliographic form, of possible sources of information for the paper. It is recommended that this product be completed on note cards, with each entry on a separate card. It might be helpful to the student to include the location of each source (school media center, Hayden Burns Library, etc.) on each card.

2. Note Cards

During the process of gathering data for the paper, careful notes should be taken and recorded on index cards. No information should appear in the final paper which is not on a note card. The student should keep three basic guidelines in mind: (1) no more than one main idea should be recorded on one card; (2) the source of the information, including page numbers, must be on the card; and (3) if the information is quoted directly, quotation marks must be used. The note cards can be shuffled and rearranged as the order of the content for the paper is decided.

3. Outline

The formation of the outline is the first attempt to "weed out" and sort through the information obtained to determine what data are relevant and how the final paper should be organized. Standard outline form should be used. The outline should not be so detailed as to include actual data from the note cards. In general, the outline will be two to four pages long.

4. Rough Draft

The rough draft is basically the final paper without the exact degree of concern for neatness. This is the student's last opportunity to be certain that he is working properly. It is recommended that the outline, which has been previously evaluated, be turned in with the rough draft for comparison.

5. Final Paper

The final paper is the culmination of previous products. Basically, the rough draft, with teacher-recommended changes, should be put into final form. It should consist of a title page, body of paper, footnotes, and bibliography page. Footnotes and bibliography should be done in a standard form as selected by the teacher. The final bibliography will consist of a minimum of six sources, including no more than two encyclopedias and at least one non-book source.

INTRODUCTION
SCIENCE SURVEY-PHYSICAL

State Accreditator Number. . 1354
Course Code Number 2263
F.T.E. Category. 1.10
Instructional Level. . . . . Standard

Report Card Abbreviation . . Sci Survey-Phy
Length of Course . . . . . Year
Credit . . . . . 1 Science credit
Grade Level. 10, 11, 12

Prerequisites

None

Textbook(s)

Wolfe, S. Concepts and Challenges in Physical Science. Cebco Standard Publishing, 1978.

Notes to Teachers

Changes have been made in the Course Outline and in the Performance Objectives for Science Survey - Physical. Full objectives are now included in addition to the Minimum Level Skills objectives. Students are to develop laboratory skills as well as content knowledge.

The Minimum Level Skills objectives are indicated with an asterisk (*) and the Minimum Level Skills Test (MLST) will test only those performance objectives so indicated. All MLS objectives must be taught before the MLST.

Laboratory skills are indicated by a plus sign (+). Suggested resources for teaching the laboratory skills have been listed at the end of this section of the teacher's guide. Teachers may substitute other resources for the laboratory investigations listed in the key. Additional laboratory activities are encouraged. Since further curriculum development may occur for this course, it is suggested that teachers keep a record of additional laboratory investigations and their source.

SCIENCE SURVEY-PHYSICAL

1.0 Energy: Identification and Conservation

- 1.1 Energy
  - 1.1.1 Definition
  - 1.1.2 Kinds
  - 1.1.3 Seven forms
- 1.2 Sources of Energy
  - *1.2.1 Primary source (sun-solar)
  - *1.2.2 Major sources: solar, geothermal, nuclear, wind and water, fossil fuels
  - 1.2.3 Definitions of sources and examples
- *1.3 Useful Products of Energy Sources
- *1.4 Advantages of Solar or Nuclear
- *1.5 Disadvantages of Solar or Nuclear
- 1.6 Factors of the Energy Problem
  - *1.6.1 Fossil fuel shortage (non-renewable, domestic demand exceeds domestic supply)
  - *1.6.2 Reasons for anticipated problem (waste, standards of living, and attitudes)
- 1.7 Alternatives to Fossil Fuels (Nuclear & Solar)
- 1.8 Major Government Agencies
  - 1.8.1 International Energy Agency(IEA)
  - 1.8.2 Department of Energy (DOE) and Environmental Protection Agency (EPA)
  - *1.8.3 State Energy Office (SEO) and Jacksonville Electric Authority Energy Office
- 1.9 Energy Conservation Measures, Individual
  - *1.9.1 Individual conservation actions
  - 1.9.2 Energy becomes expensive
- 1.10 Need for Balance
  - 1.10.1 Economy
  - 1.10.2 Environmental protection
- 1.11 Contributors to Science & Energy Technology

2.0 Metric System, Lab Equipment, Tables, Graphs

- 2.1 Metric Units: Length, Mass, Volume & Time
  - *2.1.1 Meter, centimeter, millimeter
  - 2.1.2 Kilogram, gram
  - *2.1.3 Liter, milliliter
  - 2.1.4 Second
- 2.2 Laboratory Equipment for Measurement
  - 2.2.1 Meter stick
  - *2.2.2 Balance
  - 2.2.3 Graduated cylinder
- 2.3 Metric Prefixes: Milli-, Centi-, and Kilo-
- 2.4 Conversion Factors
  - 2.4.1 Metric to Metric
  - 2.4.2 Metric to English
  - 2.4.3 English to Metric
- 2.5 Use of Measuring Equipment
  - +2.5.1 Meter stick
  - +2.5.2 Balance
  - +2.5.3 Graduated cylinder
  - 2.5.4 Density
- 2.6 Research Skills
  - 2.6.1 Tables & line graphs
  - *2.6.2 Interpret tables
  - *2.6.3 Interpret line graphs
  - 2.6.4 Scientific method

SCIENCE SURVEY-PHYSICAL

3.0 Atomic Structure & the Periodic Table

- *3.1 The Atom
- *3.2 Location and Charge of Protons, Electrons, & Neutrons
- 3.3 Contributors Modern Atomic Theory (Dalton, Thomson, Rutherford, Bohr, Chadwick, & Schrodinger)
- 3.4 Chemical Symbols
  - 3.4.1 Definition
  - 3.4.2 Writing chemical symbols
  - *3.4.3 Symbols of common elements (carbon, hydrogen, oxygen, nitrogen, argon, magnesium, gold, aluminum)
- 3.5 Arrangement and Use of the Periodic Table
  - *3.5.1 Elements
  - 3.5.2 Groups
  - 3.5.3 Periods
  - *3.5.4 Metals & non-metals

4.0 Interactions of Matter

- *4.1 Three States of Matter
- *4.2 Changes (States of Matter)
- 4.3 Physical State of Common Substances
  - *4.3.1 Identification
  - +4.3.2 Determination, lab. procedures
- 4.4 Changes in Matter
  - *4.4.1 Physical & chemical changes
  - +4.4.2 Chemical & physical changes in chalk
- 4.5 Solutions
  - 4.5.1 Solvent & solute
  - 4.5.2 Kinds: concentrated, saturated, dilute, super-saturated, unsaturated
- 4.6 Factors Affecting Rate of Dissolving
  - 4.6.1 Stirring
  - *4.6.2 Heat
  - 4.6.3 Particle size
- +4.7 Preparation of Solutions
- 4.8 Chemical Formulas
  - 4.8.1 Number of atoms
  - 4.8.2 Water, carbon dioxide, table salt, hydrochloric acid
- 4.9 Classification of Matter
  - 4.9.1 Elements, compounds, or mixtures
  - +4.9.2 Classify common substances
- 4.10 Types of Bonds: Ionic & Covalent
- 4.11 Chemical Equations
  - 4.11.1 Reactants & products
  - 4.11.2 Balance equations
- 4.12 Acids and Bases
  - 4.12.1 Ion characteristics
  - 4.12.2 Properties
  - *4.12.3 Litmus paper as an indicator
  - *4.12.4 Classify vinegar, lemon juice, soap, milk of magnesia, ammonia
  - +4.12.5 Classify common substances, lab procedures
- 4.13 Law of Conservation of Matter
  - *4.13.1 Application
  - +4.13.2 Confirmation
- 4.14 Nuclear Energy
  - 4.14.1 Nuclear energy (definition)
  - 4.14.2 Safety precautions

5.0 Mechanics and Energy

- *5.1 Definition of Force
- *5.2 Types of Forces: Gravitational, Electrostatic, Friction, Nuclear or Magnetic
- 5.3 Measuring Force Units

SCIENCE SURVEY-PHYSICAL

- 5.3.1 Pound-English
- 5.3.2 Newton-metric
- 5.4 Laws of Motion
  - *5.4.1 Newton's First Law of Motion
  - 5.4.2 Newton's Second Law of Motion
- 5.5 Velocity and Acceleration
  - *5.5.1 Definitions
  - 5.5.2 Calculations
- *5.6 Examples of Forms of Electrical Energy
- *5.7 Energy Transformation (Electrical Appliances)
- *5.8 Potential & Kinetic Energy
- 5.9 Definition of Work
- 5.10 Definition of Power
- 5.11 Simple Machines:
  - 5.11.1 Definition
  - *5.11.2 Lever & inclined plane
  - 5.11.3 Application
  - +5.11.4 Measurement of work
  - 5.11.5 Mechanical advantage effort & resistance

6.0 Sound and Light

- 6.1 General Properties of Waves
- 6.2 Parts of Waves
- 6.3 Sound
  - *6.3.1 Description
  - 6.3.2 Media that transports
  - *6.3.3 Echo
  - 6.3.4 Wave length, frequency, and amplitude
  - 6.3.5 Frequency and pitch
  - 6.3.6 Music and noise
  - 6.3.7 Pitch on stringed instruments
  - +6.3.8 Human hearing range (oscilloscope & audio generator)
- 6.4 Nature of Light
  - 6.4.1 Visible light in electromagnetic spectrum
  - *6.4.2 Transmission
  - *6.4.3 Speed of light (300,000 km/s)
  - *6.4.4 Reflected and refracted light
  - +6.4.5 Reflection of light
  - 6.4.6 Light spectrum
  - +6.4.7 Production of color
  - *6.4.8 Transparent, translucent, & opaque objects

7.0 Electricity

- 7.1 Static Electricity
  - 7.1.1 Definition
  - *7.1.2 Examples
- *7.2 Nature of Lightning & Safety Procedures During Electrical (Lightning) storms
- +7.3 Induction and Conduction
- 7.4 Electricity and Magnetism
  - 7.4.1 Definition
  - *7.4.2 Description of current electricity
  - 7.4.3 Description of magnetism
- 7.5 Electric Circuits
  - 7.5.1 Source of electricity
  - 7.5.2 Resistor or load
  - 7.5.3 Switch
  - 7.5.4 Conducting path
  - 7.5.5 Parallel & series
  - +7.5.6 Construction of series circuits
  - 7.5.7 Fuses and circuit breakers
  - 7.5.8 Safety procedures
- 7.6 Conductors and Insulators
  - 7.6.1 Examples of conductors
  - *7.6.2 Examples of insulators
  - +7.6.3 Testing materials

SCIENCE SURVEY-PHYSICAL

8.0 Heat

- 8.1 Definition
- 8.2 Heat Transfer
  - 8.2.1 Conduction
  - 8.2.2 Convection
  - 8.2.3 Radiation
- +8.3 Heat Transfer (Expansion of Solids Using the Ball & Ring Apparatus,
- 8.4 Temperature and Heat
- 8.5 Measurement of Temperature
  - 8.5.1 Fahrenheit
  - 8.5.2 Celsius

PERFORMANCE OBJECTIVES
SCIENCE SURVEY-PHYSICAL

To demonstrate the ability to recall and apply knowledge of energy identification and conservation; the metric system, laboratory equipment, tables, and graphs; atomic structure and the Periodic Table; interactions of matter; mechanics and energy; sound and light; electricity; and heat; students will master the performance objectives listed below. Successful completion of this course is based on teacher judgement and the requirement that students pass the Minimum Level Skills Test.

Performance Objectives

1.0 Energy: Identification and Conservation

1.1 Students will identify (1) a definition of energy, (2) the kinds of energy, and (3) the seven forms of energy: mechanical, electrical, heat, light, chemical, sound and nuclear.

1.2 To demonstrate knowledge of the sources of energy, students will:

*(1) identify the primary source of energy for the earth;

*(2) identify the major sources of energy as solar, geothermal, nuclear, wind and water, or fossil fuels; and

(3) identify the definition and give examples of each source of energy.

*1.3 Students will identify the useful products of the energy sources as heat, light, motion, or current electricity.

*1.4 Students will identify an advantage of solar or nuclear energy.

*1.5 Students will identify a disadvantage of solar or nuclear energy.

1.6 To demonstrate knowledge of the factors leading to the energy problem, students will:

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* Indicates Minimum Level Skills
\+ Indicates laboratory skills

*(1) recognize that the United States uses more fossil fuels than it produces and

*(2) identify overall reasons for the energy problem as waste, standards of living, or attitudes relating to available energy supplies.

1.7 Students will identify solar energy or nuclear energy as alternatives to fossil fuels for Florida.

1.8 To demonstrate knowledge of the major government agencies attempting to deal with the energy problem, students will:

(1) identify the government agency that deals with the energy problems on an international level,

(2) identify the government agencies that deal with the energy problem on a national level, and

*(3) identify the government agencies that deal with the energy problem on state and local levels.

1.9 To demonstrate knowledge of measures that individuals may take to conserve energy, students will:

*(1) identify an individual action that would conserve energy and

(2) identify a reason why energy is becoming expensive.

1.10 Students will (1) recognize that a shortage in energy sources affects our economy and (2) identify one way of protecting the environment during the use of energy sources.

1.11 Students will recognize contributions made by scientists to science and energy technology.

2.0 Metric System, Laboratory Equipment, Tables, and Graphs

2.1 To demonstrate knowledge of metric units of measurement, students will:

*(1) identify the meter as the basic unit of metric length,

(2) identify the gram as the basic unit of metric mass,

*(3) identify the liter as the basic unit of metric volume, and

(4) identify the second as the metric unit of time.

2.2 To demonstrate knowledge of the appropriate laboratory equipment for measurement, students will:

(1) identify the meter stick as the instrument used to measure length in the laboratory,

*(2) identify the balance as the instrument used to measure mass in the laboratory, and

(3) identify the graduated cylinder as the instrument used to measure volume in the laboratory.

2.3 Students will identify milli- as .001 or 1/1000 of the basic unit, centi- as .01 or 1/100 of the basic unit, and kilo- as 1000 times the basic unit.

2.4 To demonstrate knowledge of metric and English conversions factors, students will convert measurement units (1) within the Metric System, (2) from metric to English, and (3) from English to metric.

2.5 To demonstrate knowledge of the use of measuring equipment in the laboratory, students will:

+(1) use the meter stick to find the metric length of an object,

+(2) use the balance to find the metric mass of an object,

+(3) use the graduated cylinder to find the metric volume of an object, and

(4) calculate the density of an object from data giving specified mass and volume.

2.6 To demonstrate knowledge of research skills, students will:

(1) construct tables and line graphs from data,

*(2) interpret data on a table,

*(3) interpret the relationship between two variables on a line graph, and

(4) recognize steps of the Scientific Method.

3.0 Atomic Structure and the Periodic Table

*3.1 Students will identify the atom as the basic building block of matter.

*3.2 Students will identify the location and charge of protons, electrons, or neutrons.

3.3 Students will recognize contributions made by Dalton, Thomson, Rutherford, Bohr, Chadwick, and Schrodinger to modern atomic theory.

3.4 To demonstrate knowledge of chemical symbols, students will:

(1) identify a definition of chemical symbol,

(2) identify rules for writing chemical symbols, and

*(3) identify symbols of the common elements: carbon, hydrogen, oxygen, nitrogen, magnesium, gold, aluminum, and argon.

3.5 To demonstrate knowledge of the arrangement of the Periodic Table, students will:

*(1) identify the symbol, atomic number, and atomic weight of a specified element,

(2) identify groups,

(3) identify periods, and

*(4) identify common elements as metals or non-metals based on their location on the Periodic Table.

4.0 Interactions of Matter

*4.1 Students will relate the distance between atoms to the states of matter.

*4.2 Students will identify the energy change required to change solids to liquids or liquids to gases.

4.3 To demonstrate knowledge of the physical states of common substances, students will:

*(1) identify the physical state of common substances at room temperature water, carbon dioxide, table salt, or hydrochloric acids and

+(2) use laboratory procedures to identify the physical state of common substances at room temperature.

4.4 To demonstrate knowledge of changes in matter, students will:

*(1) identify examples of changes in matter as physical changes or chemical changes and

+(2) produce physical and chemical changes in chalk.

4.5 Students will identify (1) the parts of a solution as the solvent and the solute and (2) the kinds of solutions as concentrated, dilute, saturated, super-saturated, and unsaturated.

4.6 To demonstrate knowledge of factors that affect the rate of dissolving, students will:

(1) identify stirring as a factor that increases the rate of dissolving,

*(2) identify heat as a factor that increases the rate of dissolving, and

(3) identify particle size as a factor that affects the rate of dissolving.

+4.7 Students will prepare solutions utilizing knowledge of the properties of solutions.

*4.8 To demonstrate knowledge of chemical formulas, students will:

(1) specify the number of atoms present in a chemical formula and

(2) identify formulas for common substances such as water, carbon dioxide, table salt, or hydrochloric acid.

4.9 To demonstrate knowledge of the classification of matter, students will:

(1) classify substances as elements, compounds, or mixtures and

+(2) use laboratory techniques to classify substances as elements, compounds, or mixtures.

4.10 Students will identify the ionic bond and the covalent bond as types of chemical bonds.

4.11 To demonstrate knowledge of chemical equations, students will:

(1) identify information given in a chemical equation as to which substances are reactants and which substances are products and

(2) balance simple equations by supplying the proper coefficients.

4.12 To demonstrate knowledge of acids and bases, students will:

(1) identify ion characteristic to acids (H^+) and to bases (OH^-);

(2) identify properties of acids and properties of bases;

*(3) identify litmus paper as a common indicator for distinguishing acids and bases;

*(4) identify common substances as acids or bases such as vinegar, lemon juice, ammonia, soap, or milk of magnesia; and

+(5) use litmus paper to classify common substances as acids or bases.

4.13 To demonstrate knowledge of the Law of Conservation of Matter, students will:

*(1) apply the Law of Conservation of Matter to predict the total number of grams of a compound produced when given the number of grams of each substance and

+(2) combine two substances which react, but do not give off a gas.

*4.14 Students will identify (1) nuclear energy as the energy produced when the nucleus of an atom is split or combined and (2) the function of special clothing and thick shields as safety precautions for working around nuclear reactors.

5.0 Mechanics and Energy

*5.1 Students will identify the definition of force.

*5.2 Students will identify gravitational, electrostatic, friction, nuclear, or magnetic as types of force.

5.3 Students will identify (1) the pound as the English unit of force and (2) the newton as the metric unit of force.

5.4 To demonstrate knowledge of the Laws of Motion, students will:

*(1) apply Newton's First Law of Motion to a description of a collision to predict the nature of the resulting motion and

(2) calculate the force using Newton's Second Law of Motion with specified mass of an object at a specified acceleration, $F = ma$.

5.5 To demonstrate knowledge of velocity and acceleration, students will:

*(1) identify the definitions of velocity and acceleration, and

(2) calculate the average velocity or the average acceleration when given the appropriate conditions.

*5.6 Students will select examples of forms of electrical energy.

*5.7 Students will specify the energy transformation which occurs in the use of electrical appliances.

*5.8 Students will distinguish between kinetic and potential energy when given examples.

5.9 Students will identify the definition of work.

5.10 Students will identify the definition of power.

5.11 To demonstrate knowledge of simple machines, students will:

(1) identify the definition of simple machine,

*(2) identify examples of inclined planes or levers,

(3) identify examples of machines doing work,

+(4) use laboratory techniques to measure work, and

(5) define mechanical advantage.

6.0 Sound and Light

6.1 Students will identify general properties of waves.

6.2 Students will identify the parts of a wave.

6.3 To demonstrate knowledge of sound, students will:

*(1) identify a description of sound;

(2) identify media that will transport sound;

*(3) identify the definition for echo;

(4) identify the definitions for wave length, frequency, and amplitude;

(5) recognize the relationship between frequency and pitch;

(6) distinguish between music and noise;

(7) identify ways of changing pitch on stringed instruments; and

+(8) determine the human hearing range using an oscilloscope and an audio-generator.

6.4 To demonstrate knowledge of the nature of light, students will:

(1) identify the position of visible light in the electromagnetic spectrum,

*(2) conclude that light travels in straight lines,

*(3) identify the speed of light as 300,000 kilometers per second,

*(4) identify a description of reflected and refracted light,

+(5) use laboratory techniques to demonstrate reflection of light,

*(6) identify a description of a spectrum,

+(7) use laboratory techniques to produce colors in the spectrum of light, and

*(8) identify an example of a transparent, translucent, and opaque object.

7.0 Electricity

7.1 To demonstrate knowledge of static electricity, students will:

(1) define static electricity, and

*(2) identify examples of static electricity.

*7.2 Students will identify safety measures to follow when caught in an electrical (lightning) storm.

+7.3 To demonstrate knowledge of static electricity, students will induct electrostatic charges and conduct electrostatic charges

7.4 To demonstrate knowledge of electricity and magnetism, students will:

(1) define current electricity,

*(2) identify a description of current electricity, and

(3) identify a description of magnetism.

7.5 To demonstrate knowledge of electric circuits students will:

(1) identify the source of electricity in the circuit,

(2) identify the resistor,

(3) identify the switch,

(4) identify the conducting path,

(5) identify parallel and series circuits,

+(6) use laboratory techniques to wire parallel circuits and series circuits,

(7) identify the purpose and use of fuses and circuit breakers, and

(8) identify safety measures to take when using electrical appliances.

7.6 To demonstrate knowledge of conductors and insulators, students will:

(1) identify materials which are conductors,

*(2) identify materials which are insulators and

+(3) use laboratory techniques to test materials that are good insulators and good conductors.

8.0 Heat

8.1 Students will define heat.

8.2 Students will identify examples of (1) conduction, (2) convection, and (3) radiation.

+8.3 Students will identify heat transfer in the expansion of a ball and ring apparatus.

8.4 Students will distinguish between temperature and heat.

8.5 Students will convert temperatures from (1) Fahrenheit to Celsius and (2) Celsius to Fahrenheit.

KEY TO RECOMMENDED INSTRUCTIONAL MATERIALS

Performance Objective		Instructional Implications		Resources	
Number	Topic	Teaching Time	Items on MLST	County Adopted Pages	Supplementary
1.0	Energy: Identification & Conservation	3 weeks	10	Wolfe, S., Concepts and Challenges in Physical Science, Cebco Standard Publishing , 1978.	Teacher's Guide for Senior High Science, SCSB, 1978-1979. pp. ss/p-13-25.
2.0	Metric System, Lab Equipment, Tables, Graphs	4 weeks	7	Wolfe, 1978, pp. 2-5.	ISIS Resource Units, Ginn and Co., 1977, Units 2, 4, 5, 9, 10, 19.
3.0	Atomic Structure & the Periodic Table	6 weeks	7	Wolfe, 1978, pp. 162-179.	ISIS Unit 24.
4.0	Interactions of Matter	6 weeks	12	Wolfe, 1978, pp. 156-157, 184-187, 208-219, 246-247, 268-271.	ISIS Units 7, 18, 22.
5.0	Mechanics & Energy	5 weeks	8	Wolfe, 1978, pp. 12-13, 16-73, 86-97.	ISIS Unit 18.
6.0	Sound & Light	2 weeks	8	Wolfe, 1978, pp. 110-153.	

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KEY TO RECOMMENDED INSTRUCTIONAL MATERIALS

Performance Objective		Instructional Implications		Resources	
Number	Topic	Teaching Time	Items on MLST	County Adopted Pages	Supplementary
7.0	Electricity	4 weeks	4	Wolfe, 1978, pp. 6-31.	
8.0	Heat	3 weeks	0	Wolfe, 1978, pp. 52-63.	

KEY TO LABORATORY RESOURCES

Wolfe, S. Concepts and Challenges in Physical Science. Cebco Standard Publishing, 1978.

Objective	Skill	County Adopted Text Pages	Other Resources
	Students will:		
+2.5.1	use the meter stick to find the metric length of an object.		Moson, Val. Focus on Physical Science Activity Centered Program Teacher's Guide. Charles Merrill Publishing Co., 1977, p. 5
+2.5.2	use the balance to find the metric mass of an object.		Eisler, Stock. Lab-Inquiry Text: Physical Science. Cambridge Book Co., 1972, pp. 39-40. Moson, 1977, p. 6 .
+2.5.3	use the graduated cylinder to find the metric volume of an object.		Moson, 1977, pp. 7-8. Eisler, 1972, pp. 43-46.
+4.3.2	use laboratory procedures to identify the physical state of common substances at room temperature.		Teacher-made: Display samples of common elements and compounds. Prepare a chart listing each displayed substance and the states of matter. Students will observe each displayed substance and record its physical state.
+4.4.2	produce physical and chemical changes in chalk.		Joslin, Paul. Matter, Life and Energy: Laboratory Investigations. Rand McNally Co., 1972, p. 27. Eisler, 1972, pp. 99, 102-103.

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KEY TO LABORATORY RESOURCES

Objective	Skill	County Adopted Text Pages	Other Resources
	Students will:		
+4.7	prepare solutions utilizing knowledge of the properties of solutions.	240, 243, 246-249	Schachter, M., et al. Laboratory Program for Concepts and Challenges in Physical Science. Cebco Standard Publishing Co., 1978, pp. 70-73. Moson, 1977, pp. 114-115, 119-120.
+4.9.2	use laboratory techniques to classify substances as elements, compounds, or mixtures.		Moson, 1977, pp. 52-53, 85-96.
+4.12.5	use litmus paper to classify common substances as acids or bases.		Schachter, 1978, pp. 80-81. Moson, 1977, pp. 144-145.
+4.13.2	combine two substances which react, but do not give off gases.	210	
+5.11.4	use laboratory techniques to measure work.		Schachter, 1978, pp. 20-22.
+6.3.8	determine the human hearing range using an oscilloscope and an audio-generator.		Teacher-made: Using an audio frequency generator as input frequency to an oscilloscope, the teacher reproduces 15 cps to 20,000 cps audio output and asks students to raise their hands when hearing begins and ends.

KEY TO LABORATORY RESOURCES

Objective	Skill	County Adopted Text Pages	Other Resources
	Students will:		
+6.4.5	use laboratory techniques to demonstrate reflection of light		Schachter, 1978, pp. 40-41.
+6.4.7	use laboratory techniques to produce colors in the spectrum of light.		Schachter, 1978, pp. 44-45.
+7.3	induct electrostratic charges and conduct electrostatic changes.		Moson, 1977, pp. 214-216. Joslin, 1972, pp. 73-78.
+7.5.6	use laboratory techniques to wire parallel circuits and series circuits.		Schachter, 1978, pp. 3-4.
+7.6.3	use laboratory techniques to test materials that are good insulators and good conductors.		Schachter, 1978, pp. 1-2.
+8.3	identify heat transfer in the expansion of a ball and ring apparatus.		